Engineering

FEB 20 1931

THE ILLUMINATING ENGINEER

THE JOURNAL OF GOOD LIGHTING

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AND
ILLUMINATION

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OFFICIAL ORGAN of
The Illuminating Engineering Society
(Founded in London, 1909; Incorporated 1930)
and of
THE ASSOCIATION OF PUBLIC LIGHTING ENGINEERS
(Founded 1923; Incorporated 1928)

Vol. XXIV

February, 1931

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Special Features:

Glasses for Use with Invisible Light—Lighting in Coal Mines—Highway Accidents by Day and Night—Lighting of Offices and Public Buildings—Light Distribution of Airway Beacons—Recent Developments in Gas Lighting—News from Abroad, etc.

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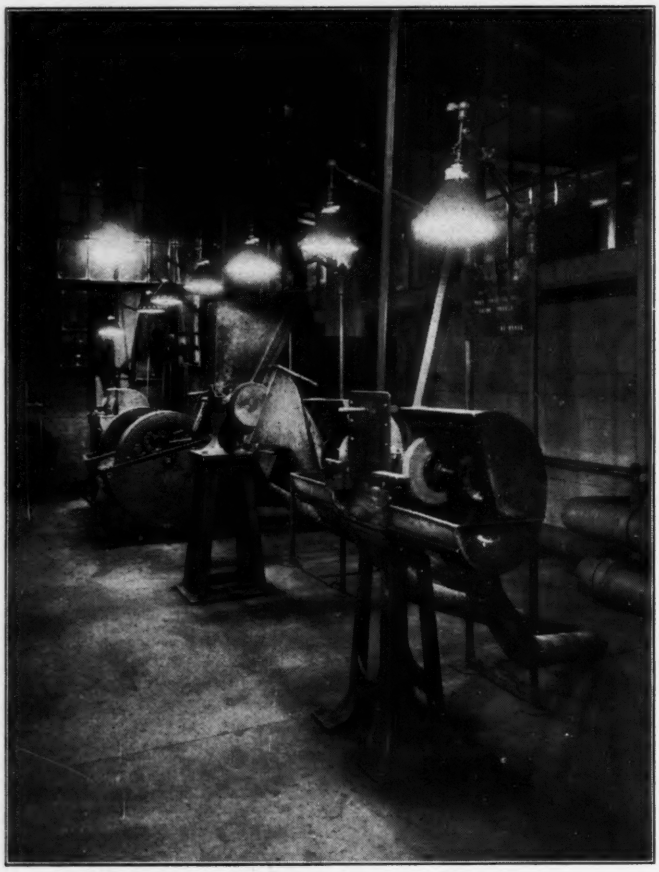

Some of a large number of gas-lighted power-driven machines in a London Engineering Shop. Each lighting unit is fixed on a universal swivel arm, which enables the machinist to adjust the position of the light to suit his own comfort and the class of work on which he is engaged. Some of the lamps are used over large grindstones where the fabric of the mantle might be damaged by flying material from the work. The bases of the conical reflectors are therefore closed in with patent wired glass discs, which do not splinter and which prevent any flying pieces from reaching the mantles. Illumination tests recently taken on the working points of the machines give illuminations ranging from 9.7 to 20.8 foot-candles.

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THE ILLUMINATING ENGINEER

LIGHT LAMPS FITTINGS AND ILLUMINATION

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Edited by J. STEWART DOW

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Glasses for Use with Invisible Rays

MEMBERS of the Illuminating Engineering Society are coming to expect from Dr. English an annual demonstration of the properties of glass. In previous years the "illuminating" qualities, thermal endurance and durability of glass have been discussed. In his paper, read on December 12th, Dr. English reviewed the conditions desirable in glass intended for, to facilitate, or impede the transmission of invisible radiation (ultra-violet and infra-red rays).

The paper was enlivened by numerous striking experiments. As Dr. English truly pointed out, such radiation is always present in some degree, whether the illuminating engineer wants it or not. Therefore it is expedient for him to know something of the properties of glasses which facilitate or hinder their passage.

For many years the influence of ultra-violet rays in causing certain chemical changes, and especially charming fluorescence phenomena, has been known. Their therapeutic value, as present in sunlight, is also an old story. It is, however, only within quite recent years that the public has been made aware of their existence through the introduction of "artificial sunlight" and the wide publicity given to their possibilities as an aid to health. This movement has had two results: it has created a vogue for varieties of window glass admitting a maximum of natural ultra-violet radiation; it has also encouraged the development of various artificial sources rich in these rays, which are somewhat indiscriminately lumped together under the term "artificial sunlight." The widespread discussion of their alleged hygienic value has had at least one good effect—it has led to a closer examination of the ultra-violet spectrum, and has brought about a keener recognition of the varying qualities of different regions. It has also enlarged our knowledge of the behaviour of different glasses.

A fundamental point in the production of glasses designed to be permeable to ultra-violet light is the avoidance of the familiar enemy, iron oxide, which must be reduced to the smallest possible proportions. Apparently iron oxide is less injurious in the ferrous than in the ferric state, hence the practice of producing glasses under reducing conditions. This benefit is apt to be transitory, however, for the influence of sunlight causes gradual conversion back to the ferric state. This process of "solarization," which may take from three to six months to reach completion, causes a progressive diminution, which may vary from 7 to 20 per cent., in the transparency to the ultra-violet rays. The main aim would seem to be to make the percentage of iron oxide present as small as possible in the first instance. Iron oxide, however, whilst an enemy when we desire to admit ultra-violet rays becomes a friend when our object is to obstruct a passage of infra-red (heat) rays, though, in this case also, it appears desirable to retain the iron oxide in the ferrous condition.

Equally interesting was the author's brief survey of ultra-violet lamps, and especially the ingenious new lamp utilizing a tungsten arc, with a pool of mercury below it, within a hermetically sealed glass envelope. Here, apparently, we have, for the first time, a lamp capable of being used on ordinary house circuits, and yet yielding a substantial amount of ultra-violet energy. Such a lamp should enable ultra-violet testing outfits to be made somewhat simpler and less costly. At present the cabinet, comprising a quartz-tube mercury-vapour lamp, screened by Wood's glass (which allows the ultra-violet to pass but is practically opaque to visible light) is a somewhat cumbrous and expensive item, and, perhaps, for this reason, is much less widely known than it deserves to be.

To our mind, the application of ultra-violet rays as a new process of analysis is full of interest. Dr. English illustrated a few of these applications, which depend on the excitation of fluorescence; others were mentioned in the course of the discussion. Amongst the more familiar applications are the discrimination between real and spurious gems, and between natural and "cultured" pearls; the detection of incipient mildew in cotton; and the recognition of ringworm in hair. Even more fascinating are the applications of the process to the detection of repairs and fakes in postage stamps, pictures and antique furniture.

Finally, our knowledge of the numerous gradual changes that may be brought about by exposure to ultra-violet light is continually extending. The fading of pigments is one of the most familiar of such processes. It is now possible to test the permanency of colours by the aid of artificial sources of ultra-violet energy. As in the case of "artificial daylight," we have here a case where artificial methods may very usefully supplement natural resources—at their best, weak and capricious in the short winter days of countries in the northern hemisphere.

The Lighting of Coal Mines

THE remarks on the above subject made by the Secretary for Mines, Mr. Shinwell, in the House of Commons, on December 3rd (see p. 35), recall to our minds one problem that is always with us, and is amongst the most difficult awaiting solution by the illuminating engineer. Whilst the economic causes of unrest in the mining industry are evident enough, it has always struck us that the trouble is also associated with the peculiar discomfort of the miner's life, lived underground to such a great extent and cut off from the stimulus of natural light, which the rest of us accept as a matter of course.

But, quite apart from the physical influence of absence of sunlight, there is the additional strain of an hazardous occupation, carried out habitually in underlighted conditions. Many factories, even to-day, are, in the judgment of lighting experts, imperfectly illuminated, though owners and managers may hold a different opinion, and may not always be easy to convince. But, in the case of coal mines, there is no difference of opinion. Everyone must admit that the illumination provided at the coal face is far below the absolute minimum requisite for health, safety and efficiency.

The ill-effects of this inadequate illumination are well established. That it is prejudicial to safety and productive of industrial fatigue can scarcely be questioned. At a meeting of the Illuminating Engineering Society held rather more than 10 years ago, Dr. Llewellyn gave a striking account of the actual conditions in mines,* pointing out that the illumination derived from the portable lamp of that time, situated, say, 8 ft. from the coal face, was less than one hundredth of a foot-candle, whilst the dark coal surface reflected but a minute proportion even of this meagre supply of light. Small wonder that the ophthalmic surgeons present at this meeting were practically unanimous in ascribing the disease of "miner's nystagmus" mainly to working under such abnormal lighting conditions.

With such low illumination, even a moderate gain is of great significance, and the higher candle-powers rendered possible by somewhat increasing the weight of the miner's lamp may well prove worth while. It is, however, by no means certain that elimination of glare in these sombre surroundings is not quite as important. Mr. Eric Farmer has shown that merely covering the filaments by a diffusing cylinder led to substantially improved seeing power.† Others have declared that the adoption of a yellow glass envelope round the lamp bulb is favourable to vision, and in some degree a precaution against the development of nystagmus—though this seems to require confirmation.

Hitherto we have been speaking of those situations in a mine where safety lamps only may be used. Whether existing regulations are unduly drastic, and whether electric wiring can be rendered sufficiently safe for use in many such situations, is well worth consideration. At the date of Mr. Farmer's paper Dr. Thornton had already proposed the use of low-voltage alternating currents of relatively high frequency; even then floodlighting at the coal face had been installed in certain Scottish mines with success. But, setting aside workings where there is danger of gas, there are doubtless many sections of coal mines where electric wiring can be quite safely used, and where very much higher illuminations than are at present available would be fully justified; it is also recognized that surface lighting might often be considerably improved with advantage.

* *The Illuminating Engineer,* March, 1920, pp. 67–79.

† *The Illuminating Engineer,* February, 1926, pp. 37–42.

Highway Accidents by Day and Night

IN our last number* we commented upon some statistics obtained in France, which served to indicate the important part played by lighting in relation to street accidents. Other instructive data have recently been compiled in the United States of America, and are the subject of reference in the most recent issue of the *Transactions* of the Illuminating Engineering Society (U.S.A.). An analysis of all traffic fatalities on the state roads of Indiana during the twelve months ending August 31st, 1930, was made by Mr. K. M. Reid, who is associated with the Nela Park Engineering Department of the General Electric Co. (U.S.A.) in Cleveland, and Mr. A. H. Hinkle, Superintendent of Maintenance on the Indiana State Highway Commission. The results of this survey were recently presented in tabular form before the American Society of Municipal Engineers.

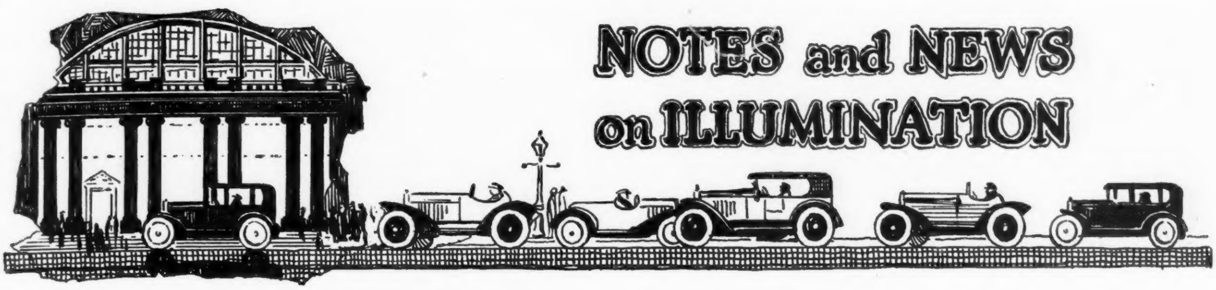
It is regarded as significant that of the total fatal accidents involved, 37 per cent. occurred during the day, 9 per cent. during dusk, and 54 per cent. after dark. This strikes us as a very considerable proportion indeed—we believe much greater than is indicated in such statistics for cities as we have seen. It is possible that the ratio of night to day accidents in cities may differ from that for rural highways—a point that certainly deserves study.

The following quotation from Mr. Reid's paper is given: "Based upon a traffic survey, Mr. Hinkle estimates that about two-thirds of the total 24-hour traffic on the state roads of Indiana is during the daytime. This means that, after daylight has failed, or is failing, about one-third of the traffic produces about two-thirds of the fatalities. The relative night hazard, therefore, is about four times the day hazard. There would seem to be ample justification for comprehensive trials of highway lighting to determine to what extent it will reduce this appalling night hazard."

We again commend this matter to the attention of the Association of Public Lighting Engineers, whose members are in a particularly good position to collect useful information. (It may be recalled that the Association, at its annual meeting in Leicester last year, decided to form a committee to deal with safety.) Apart from the inferences to be drawn from general statistics, much might be learned by the study of accidents of a certain character, for example those occurring at busy crossings. We recall that in his paper before the National Safety First Congress last year Mr. Beveridge was able to quote encouraging data from Edinburgh, where the adoption of luminous-signal control at certain busy centres had apparently led to a material diminution in accidents. There must be many cities throughout the country where close and cordial relations exist between the Public Lighting Department and the police, and where there are already records of street accidents which would well repay analytical study.

It may perhaps be thought that we dwell too insistently on the relation between public lighting and safety. We do emphasize this point because, to our mind, it furnishes one of the strongest possible arguments in favour of good street lighting; there is here a possibility of establishing a case such as would furnish a basis of action by Government Departments—and it may be on these lines, rather than by the relatively slow process of influencing public opinion, that the greatest possibilities of progress exist.

* *The Illuminating Engineer,* January, 1931, p. 2.



The Illuminating Engineering Society

(Founded in London, 1909)

ANNUAL DINNER.

We are asked to remind members that the **Annual Dinner** of the Society is being held at the Trocadero Restaurant on **February 10th** (7 for 7-30 p.m.). Tickets (price 15s., exclusive of wine) may be obtained from the Hon. Secretary (Mr. J. S. Dow, 32, Victoria Street, London, S.W.1). The dinner will be followed by dancing, and members may bring ladies as their guests. It is hoped that there will be quite as good a gathering this year as on previous occasions. Will any members who have not yet applied for tickets, and desire to attend, kindly get in touch with the Hon. Secretary *as soon as possible.*

FORTHCOMING MEETINGS.

The next meeting of the Society will be held in the lecture theatre of the Home Office Industrial Museum (Horseferry Road, Westminster, S.W.1), at 6.30 p.m., on **Wednesday, February 18th,** when the evening will be devoted to a series of **Problems in Illuminating Engineering.** Such meetings have invariably proved successful in the past, and there will no doubt be a good attendance. A number of interesting communications are already promised; and any members who have contributions they desire to include in the programme are asked to let the Hon. Secretary know without delay.

On **Wednesday, March 18th,** there will be a meeting, at 6.30 p.m., in the lecture theatre of the E.L.M.A. Lighting Service Bureau (15, Savoy Street, London, W.C.2), when Mr. H. T. Young will present a paper reviewing **Recent Progress in Domestic Lighting.**

Lectures to Architectural Students

By the courtesy of Mr. W. C. Clinton we give below a syllabus of four lectures on illumination, which he is delivering to architectural students. This is the first course of its kind to be arranged at University College —in fact, we do not recall any similar lectures to architectural students being planned at any other educational institution—and the experiments will be watched with general interest. The syllabus of the lectures is as follows: —

(1) PRODUCTION AND APPRECIATION OF LIGHT.
Natural and artificial light——The human eye—Electric lamps—Types available—Future tendencies.

(2) CANDLE-POWER AND ILLUMINATION.
Units — Standards — Photometers — Colour variation and its effect on illumination—Reflection and absorption at wall, floor and ceiling surfaces.

(3) INDOOR ILLUMINATION.
Daylight and artificial light—Direct and indirect methods and their combination—Glare and its abolition —The value of shadows—Lighting of public buildings and auditoria—Office lighting—Domestic lighting—The economic aspect.

(4) OUTDOOR ILLUMINATION.
Apparatus required and its disposition—Factors involved in the lighting of streets and open spaces devoted to different uses — Floodlighting — Sign lighting.

Street Lighting in Newcastle-upon-Tyne

We notice in the *Newcastle Chronicle* a reference to the lighting of that city, which is under the supervision of Mr. Robert Davison. A step of some importance is the determination to abandon the pressure-wave system of controlling the gas lighting and to substitute clock control—a change which is likely to prove advantageous both to the gas company and to consumers. It is recalled that Newcastle has now over 290 miles of lighted streets. There are in action 9,850 gas lamps and 5,589 electric lamps; 1,300 new lamps have been installed since the recent housing schemes were commenced. Another point that has received special attention in Newcastle is the upkeep of mantles, about 20,000 of which were used by the Lighting Department last year. On the average, each nozzle requires only 2.8 mantles per annum—a creditable figure, and very much less than that usual only a few years ago.

Striking Show-Window Displays

We have previously singled out Oxford Street as specially attractive to those interested in novel show-window displays. One of the most recent is that staged at the new Drage premises, the frontage of which, with its combination of grey granite and polished metal, is in itself unusual. The chief feature of the window-lighting equipment is the complete system of several rows of units equipped with screens of various colours, so that the tint of the light can be varied to suit the subject. The manner in which the rows of lighting units are boxed in as an integral element in the window design is also good. The only criticism that one might make is that from some angles the "works" are rather too evident; but with an island window this is almost unavoidable. One may take the opportunity to comment on the growing tendency to make use of light in show windows, not only for purposes of illumination but as a decorative element in the display. A good instance of this is afforded by the Lyons' Oxford Street Corner House, where 225 feet of neon tubing have been incorporated in the Christmas display. According to *Signs*, the credit for this innovation is due to a lady, Miss R. Harvey. Lyons seem to be making a feature of this idea, if one may judge from the windows of another of their branches, in the vicinity of Leicester Square, where luminous crescents form part of a decorative scheme on Oriental lines.

Light on the Underground

The breakdown on the tube system during the evening rush period, on January 22nd, was a somewhat serious one. It is a matter for congratulation that apparently there was no loss of life or injury to passengers, who only suffered a considerable degree of inconvenience. Whilst one recognizes the wonderful service which the underground railway system of London performs, and the somewhat severe tax which the ever-growing traffic imposes on it, one cannot escape the feeling that breakdowns have been somewhat more frequent during recent years. If this is so, the need for something more than a purely perfunctory "emergency lighting" seems evident. The confusion during the stoppage on January 22nd shows how absolutely dependent are the tubes on artificial light, not only in the trains and on the platforms, but in the passages, on stairways and at exits. The writer has still a vivid recollection of three hours spent in almost complete darkness in a tube stoppage some years ago (fortunately he escaped the mishap on January 22nd). It ought not to be beyond the wit of man to ensure that whatever else goes wrong there will always be adequate lighting available.

The Illuminating Engineering Society of Australia

For some time there has been evidence of growing interest in illumination in the British Colonies and Dominions. This has recently led to an interesting development—the formation of the Illuminating Engineering Society in Australia, the secretary of which is Mr. A. F. Brown (The Grace Building, King, York and Clarence Streets, Sydney). We gather that the aims and general constitution of the new body resemble those of the Illuminating Engineering Society of London, and we are sure that many opportunities for co-operation between the two bodies will present themselves. We hope that the new society will not "hide its light under a bushel," but will enable us to present to our readers all over the world periodical accounts of its work in Australia. Meantime we wish the Illuminating Engineering Society of Australia all possible success and prosperity.

Light Reflection Factors of Acoustic Materials

Some notes on the above subject were presented at the twenty-fourth Annual Convention of the Illuminating Engineering Society (U.S.A.), by Mr. A. L. Powell and Mr. C. L. Dows, and appear in the December issue of the Society's *Transactions*. The use of sound-absorbing materials is becoming increasingly common, and the authors give an imposing list of substances designated by various trade names. The reflecting power varies within wide limits from only 5.9 and 8.3 for dark-brown corkboard and chocolate-coloured "corkoustic," to over 75 per cent. yielded by "cushocel" (white finish) and some other materials. It will naturally be suggested that materials may be painted and the light-reflecting power thus improved. Oil paint, however, is liable to fill up the small apertures in the material and thus impair its acoustic properties, whilst water paints, which are less open to this objection, need renewal at frequent intervals.

Illumination and Output

SOME DATA BEARING ON THE TEXTILE INDUSTRY.

An elaborate and fruitful analysis of the part played by lighting conditions in the textile industry, for which Dr. N. Goldstern and Dr. F. Putnoky are responsible, has been appearing in *Light und Lampe* as a serial contribution. A feature is the close attention paid to the relation between intensity of illumination and output and quality of work—the latter being judged in terms of mistakes, broken threads, shuttles out of action, etc. A considerable number of diagrams are used to illustrate these results, and it would require detailed study to appreciate their true significance. A glance, however, reveals several interesting points. Whilst, as might be expected, increasing illuminations generally tend towards increased output, there is a marked difference in the relation according as the work is done in light or dark material. It is also noteworthy that conclusions in regard to quality and output do not always coincide (e.g., there may be cases where quality continuously improves when saturation point as regards quantity has been reached, and vice versa). In one diagram before us relating number of stoppages to illumination the curves for dark and light material differ in shape, yet start together at a low illumination and rejoin at a high illumination (over 2,000 lux). Again, whilst efficiency improves steadily with higher illumination, both for dark and light material, we note one diagram showing a different conclusion in respect of errors—for in this case the curves for dark and light material *cross* at 1,500 lux, and the former shows a well-marked minimum near 750 lux. The authors' final conclusions seem to suggest that maximum efficiency is attained somewhere near 1,550 lux (about 150 foot-candles), whilst the economic maxima usually occur at 600–700 lux (60–70 foot-candles).

It is pointed out that the tests were conducted only with female operators, and that different results might be obtained with thread of a different diameter (as in jute weaving) or a different variety of surface (e.g., artificial silk).

A Factory without Windows

There has been some discussion regarding the desirability and feasibility of designing large office or factory buildings in congested areas without light wells or windows for the admission of natural light. According to *Industrial Engineering*, a factory designed on this basis is now being erected in Fitchburg, Massachusetts. The structure, it is stated, will cover nearly two city blocks. There will be no windows in walls or ceilings, but "adequate systems will be installed for scientific lighting, ventilation and noise absorption, making use of acoustical ceilings and other means." The lighting system aims at a uniform value throughout the building of 20 foot-candles; provision is made for emergency lighting from storage batteries. Careful attention will be paid to psychological aspects in the choice of colours. Two working shifts, from 5 a.m. to 2 p.m. and from 2 p.m. to 11 p.m. are planned. It is hoped that the new methods will result in an increase in human efficiency of as much as 33 per cent.!

Illuminated Glass

The advent of "architectural lighting," seems likely to open up new possibilities to glass designers. Not only is there a new demand for sheet glass of diffusing or decorative character, but also an opening for pictorial design. In the past practically the only opening for opportunity for the skill of the artist in window glass has been in churches. Illumination of stained glass windows by natural light has, however, manifest limitations. If such glassware comes to be widely used as an element in artificial-lighting schemes the possibilities of novel treatment would be much greater. Evidently the use of extensive luminous surfaces may cause conventional fittings to take a minor position in the lighting scheme; they may even become unnecessary. We notice in *Lux* a discussion of the design of decorative glass panels, which are being exploited to a considerable extent in French lighting schemes. In the same issue there is also a note on another development, the use of light for mural decoration. Three main methods are described. The first of these is based on the use of a fluted projecting border, with concealed coloured lamps in front; pleasing coloured light and shadow effects are thus produced. A second device consists in the use of projecting wall elements which can be illuminated from either side by obliquely directed coloured light, and the third, based on the use of lamps inserted in a box border with a semi-translucent front, permits the production of luminous flowers and similar decorative devices.

TECHNICAL SECTION

COMPRISING

Transactions of The Illuminating Engineering Society and Special Articles

The Illuminating Engineering Society is not, as a body, responsible for the opinions expressed by individual authors or speakers.

Glasses for Use with Invisible (Ultra-Violet and Infra-Red) Rays

By S. ENGLISH, D.Sc., F.I.C., F.Inst.P.

(Paper read at the Meeting of the Illuminating Engineering Society, held in the Lecture Theatre of Messrs. Holophane Ltd., Elverton Street, Vincent Square, Westminster, London, S.W.1, at 6 p.m., on Friday, December 12th, 1930.)

AT first sight, it may appear anomalous to present to a body of illuminating engineers (who, we are told in a recently published book, should be known as "brightness engineers") a paper dealing with invisible rays; but, on further consideration, the anomaly disappears, for wherever we produce visible radiation we practically always, if not invariably, produce invisible rays at the same time. Whether we want them or not, these invisible rays are present, and we therefore need to know something about glasses for transmitting and for absorbing such rays. It is only by having at our command a range of such glasses that we can control and make use of such radiations; but before passing on to this branch of the subject it is necessary, first of all, to consider briefly the nature of the invisible rays with which we have to deal.

The Spectrum.

Everybody knows that the so-called white light of day is not a simple homogeneous light, but is a composite light consisting of many shades of the simple colours, red, orange, yellow, green, blue and violet, all blended together. This composite nature of white light is demonstrated in the formation of rainbows in the sky and in the production of spectra in the laboratory. But the bands of coloured light we see in the rainbow do not represent the total radiations present in sunlight. It is well known that the direct rays of the sun carry with them a considerable amount of heat. The same feature is a marked characteristic of most of our artificial sources of light. These heat rays find no place in the visible spectrum, but by the use of suitable instruments they can be shown to lie in a broad band beyond the red end of the visible spectrum. For this reason they are spoken of as "infra-red."

In the same way that the red colour is not the end of the full spectrum in that direction, it can be shown by suitable apparatus that the violet colour is not the end of the full spectrum in the other direction, for here again, beyond the visible violet there lies a band of invisible rays which are known as "ultra-violet." These ultra-violet rays are characterized by their remarkable chemical and biological activity. These invisible rays—both infra-red and ultra-violet—are produced by exactly the same type of ether waves as produce visible light, and they obey the same physical laws. The only essential difference is in their wavelengths. The visible spectrum is generally supposed to terminate at the violet end at about 390Mμ; the ultra-violet extends from this figure down to about 14Mμ; beyond this there lies a band of X-rays. At the other end of the spectrum the red is generally regarded as becoming invisible at about 780Mμ, and from this figure upwards there lies the infra-red zone. Encroaching on the upper end of this zone, and stretching to enormous wavelengths, there are the Hertzian and wireless waves. These facts are set out in Fig. 1, which serves to show how small a range of these wavelengths is occupied by the light-producing rays.

Just as different sources produce lights of different quality, i.e., consisting of different proportions of the various component colours, so it is found that the invisible rays produced by different sources vary enormously. The range of rays actually found in sunlight at the earth's surface is indicated in Fig. 1, but the range produced by artificial sources often extends into both the ultra-violet and the infra-red, much beyond these limits. It may be taken almost as axiomatic that radiations which are found in the sun's spectrum are not harmful to ordinary animal or vegetable life, but that rays which are produced artificially and lie beyond that range may be harmful in some way if used indiscriminately.

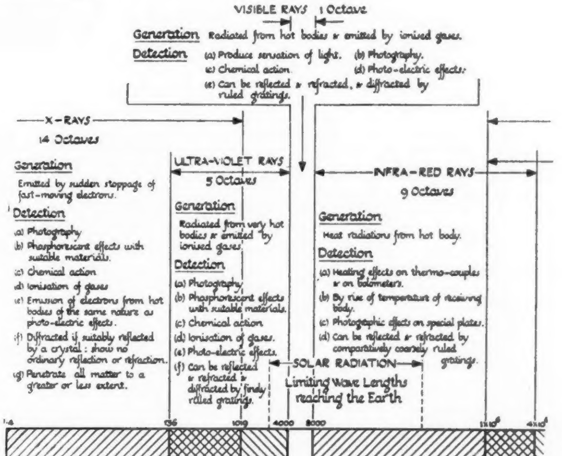


FIG. 1.—Characteristics of certain radiations.

The Ultra-violet Rays.

As already mentioned, these rays are characterized by their strong chemical and biological activity. It is this latter feature that has brought these invisible rays into prominence during recent years, for modern medical research has shown that a certain small band of these rays are very important indeed in promoting good health. It has long been known that direct sunlight has the power of killing germs and bacteria, and of producing a ruddy glow of health on the face of the outdoor worker, but it was not till recent years that it was shown that the active rays in these respects were not the visible rays of sunlight, nor even the whole of the ultra-violet rays—but only a very narrow band, lying quite near to the limit of the sun's spectrum and extending only from about 295Mμ to about 320Mμ. The band has become known as the health rays. Now ordinary window glass, and the glass from which ordinary

electric lamps and lighting units are made, though transparent to the rays of visible light, do not transmit this particular zone of invisible rays. Thus the light inside a room glazed with ordinary window glass, or lit by an ordinary electric lamp in an ordinary glass unit, is very different from the direct sunlight and skylight out of doors. Besides a colour difference, it is deficient in those important health rays. If it is desired to get the full-quality sunlight indoors it is necessary to use special ultra-violet transparent glass, and also, in the case of artificial lighting, to use special lamps.

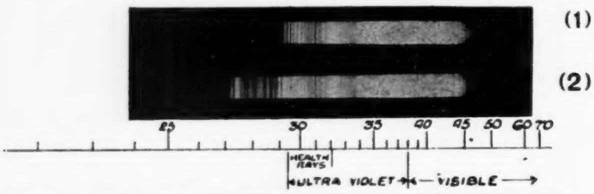


Fig. 2.—The Ultra-violet Transparencies of two glasses of similar composition; (1) melted under ordinary conditions, (2) melted under reducing conditions.

Glass manufacturers, with the assistance of glass technologists, have not been slow to tackle this problem of producing glasses which transmit these invisible health rays. The ideal material for transmitting these rays is clear silica, for it is transparent to ultra-violet rays of wavelength very much shorter than any found in the sun's spectrum; but, unfortunately, owing to manufacturing difficulties, it is too expensive for general use. Although ordinary glass generally consists of 70 to 75 per cent. silica, its ultra-violet transmission is not comparable with that of pure silica. Technologists interested in this subject have found that certain constituents of glasses are very detrimental to ultra-violet transparency; others are less dangerous, while just a few show very good transparencies. The two constituents which are most favourable to ultra-violet transmission are silica and boric oxide; the two most dangerous constituents are iron oxide and titania. We thus once more come across the illuminating-glass manufacturers' old enemy—iron oxide—with its tantalizing habit of changing over from the ferrous to the ferric state, and vice versa, under certain sets of conditions. In all ultra-violet glasses everything possible is done to reduce the iron oxide content to the lowest possible limit, and in the successful glasses it is below 0.02 per cent. Technologists working on this subject soon found the importance of a very low iron oxide content of their glasses, and in 1928 Turner and Starkie followed this up by preparing in platinum crucibles a series of soda-lime-silica glasses with very small and varying iron oxide contents, and showing that as their iron oxide increased from 0.005 per cent. to 1.01 per cent. the limit of ultra-violet transparency changed from about 250Mμ to about 325Mμ.

But this is not the end of the story so far as iron oxide is concerned, for the earlier workers on this matter found that when iron was present in a glass in the reduced or ferrous condition it was much less dangerous than when present in the ferric condition. This was for some time, and in some cases still is, regarded as a secret, but at the present time all ultra-violet transparent glasses are melted under reducing conditions, and reducing agents are usually included in the batch mixture. These reducing agents are generally of a carbonaceous or organic nature, though in several cases attempts have been made to use inorganic agents; for example, chlorides are sometimes added to the mixture in the hope of converting the iron into ferrous chloride, which may volatilize and pass out of the glass altogether, or, alternatively, it may dissolve in the glass in a harmless form. The improved transparency to ultra-violet obtained by melting a glass under reducing conditions is shown in Fig. 2, in which the two bands show the extent of the transparency of an ordinary glass (1,—upper) melted under ordinary conditions, and (2,—lower) melted with an inorganic reducing agent.

Working along these lines, several very promising ultra-violet glasses have been produced showing fairly satisfactory transparencies to the invisible health rays, to which ordinary glasses are opaque. The transmission of one such glass is shown in Fig. 3, in which the upper band shows the spectrum of the source of light (Fe arc) used for testing purposes; the second band shows the extent of this spectrum transmitted by the ultra-violet glass under test; and the third band, the extent of the transmission through an ordinary glass. From this photograph and the associated wavelength scale it is clear that the ultra-violet glass transmits the whole range of the ultra-violet rays found in the sun's spectrum. The difference in this respect between special and ordinary glasses may be demonstrated visually in the following way. A source of light rich in ultra-violet rays is encased, except for an aperture in which is placed a quartz plate with a very thin silver backing. This silver film is just thick enough to prevent the passage of rays of visible light, but such a film has the power of transmitting a band of invisible rays in the neighbourhood of 310μ–320μ (i.e., near the top of the health-ray zone). In a darkened room, therefore, such a combination produces no visible effect, but if a fluorescent substance such as a solution of fluorescein, contained in a silica tube, be placed in front of the aperture, a bright greenish-yellow fluorescence is seen. If now a piece of ultra-violet transparent glass be placed in between the lamp and the tube, the fluorescence remains, but slightly diminished in intensity, indicating the passage through the glass of the major portion of the invisible rays of approximately 310Mμ to 320Mμ wavelength, but if a piece of ordinary glass be placed in this position the fluorescence immediately disappears, indicating, of course, that the invisible rays causing it have been absorbed by the ordinary glass.

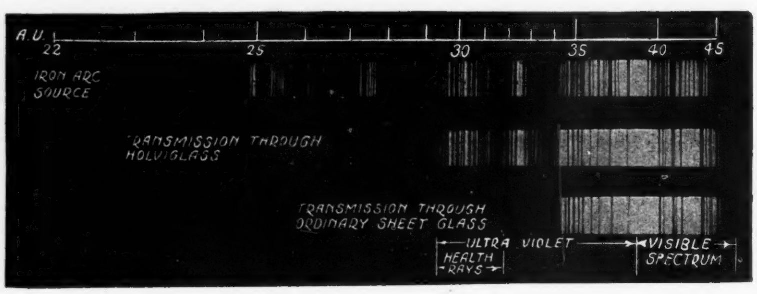


Fig. 3.—Showing the relative transparency of various glasses.

Such demonstrations as this and the spectrum transmission photographs given in Fig. 3 only give a qualitative test of ultra-violet transparency. Quantitative determinations of the proportion of the incident ultra-violet rays transmitted throughout the range from 240Mμ to 390Mμ show that all ultra-violet glasses are not equally efficient in transmitting the zone that is most important—namely, that from 295Mμ to 320 Mμ. Fig. 4 shows the percentage transparencies of several commercial ultra-violet glasses and an ordinary glass in the near ultra-violet. At 310Mμ the best of these glasses gives a transmission of about 73 per cent.—more transparent glasses have been prepared, but they are not satisfactory glasses in other respects. The difference in the shape of these curves is no doubt due to the composition of the glass; boric oxide tends to produce a high transmission with a sharp cut-off, as exhibited by Curve H—lime tends to give a flatter curve, as seen in Curve A1. This advantage in favour of boric oxide needs using very carefully, for, if it is pressed too far, numerous manufacturing difficulties arise that render the glass bad in every respect but ultra-violet transparency.

If that were the end of the story ultra-violet glass manufacturers would be comparatively happy, but it is not. The enemy—iron oxide—once more makes its presence felt. When these glasses are exposed to ultra-violet radiation—either from the sun or from an artificial

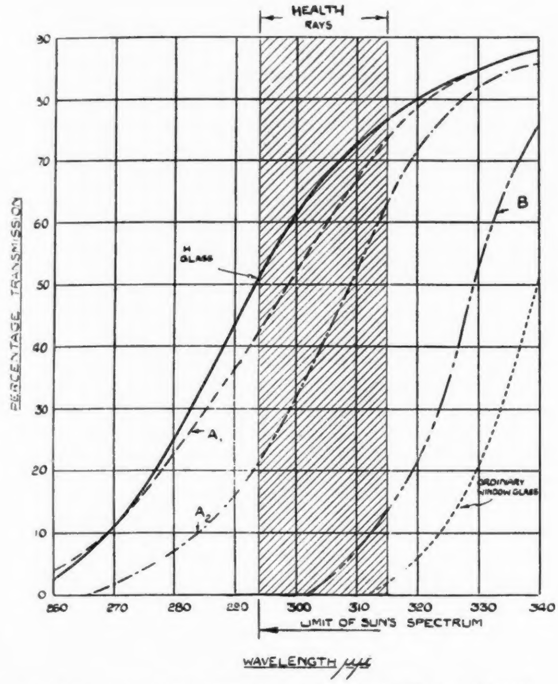


FIG. 4.—Ultra-violet Transmission of various Window Glasses.

source—the iron oxide (though very small in amount) which has been brought to the ferrous or chemically reduced condition by special manufacturing processes is transformed to the ferric or more highly oxidized condition. Because of this change, a glass which has a transmission of, say, 60 per cent. of the health rays when new may have this figure reduced to 50 per cent., or perhaps even 40 per cent., after its iron oxide has come to an equilibrium condition. Of course, when once this equilibrium has been reached for any particular set of conditions, no further change takes place unless the conditions of exposure of the glass are altered. In the case of exposure to sunlight, this change, which is spoken of as "solarization," often takes from three to six months to reach completion. All commercial glasses suffer from this defect, but to varying degrees; N.P.L. figures for the transparency in the health-ray zones for one glass show a loss due to severe artificial ageing of 20 per cent. at 300Mμ, and for another glass of only 7 per cent. The difference between two different makes of glass in this respect is indicated in Fig. 5, in which the upper three bands show the extent

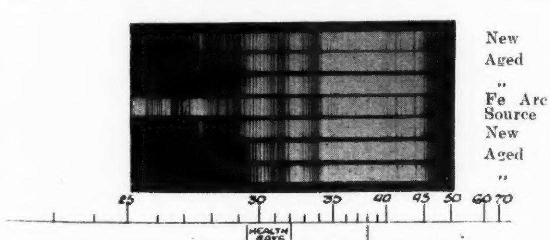


FIG. 5.—The Effect of Artificial Ageing on two types of ultra-violet glass.

of the transmission of one type of glass when new and after two periods of artificial ageing (five and ten hours respectively); the lower three bands show the extent of the transmission of another type of glass when new and after identical ageing processes. It is clear that the glass represented by the upper bands maintains its ultra-violet transparency very much better than that represented in the lower three bands.

New Ultra-violet Lamps.

For many years it has been known that certain arc lamps—with metal or impregnated-carbon electrodes—and mercury-vapour lamps in silica tubes emit copiously ultra-violet rays. These lamps have been used very successfully for curative purposes by medical men, but they need to be used very carefully, for by their use it is possible to concentrate on to a person under treatment much more ultra-violet than he would get by exposure to the sun, and also rays of much shorter wavelength, which are certainly injurious to the eyes, and also injurious in a general way if the dose is not carefully controlled.

The ordinary electric lamp does not emit any appreciable quantity of the ultra-violet rays in the 295Mμ to 320Mμ zone, but lamp manufacturers and investigators, in their desire to provide an artificial light with sunlight qualities, have developed several types of new lamps, each of which, it is claimed, is perfectly safe to use in a general way and without medical control. Each of these lamps makes use of ultra-violet transmitting glass, and the characteristics of such glasses are therefore of interest to manufacturers of these newer lamps, and also to potential users of such lamps.

One of these new lamps is very similar to the ordinary gasfilled lamp. It has a tungsten filament, which is overrun to such an extent that the ultra-violet emission is materially increased, though the average life of the lamp is reduced to 300 hours. The bulb consists of an ultra-violet transparent glass of bluish colour and acid finished inside. A spectrum photograph of the ultra-violet emission from this lamp is given in the second band of Fig. 6. Another type of ultra-violet lamp is a combi-

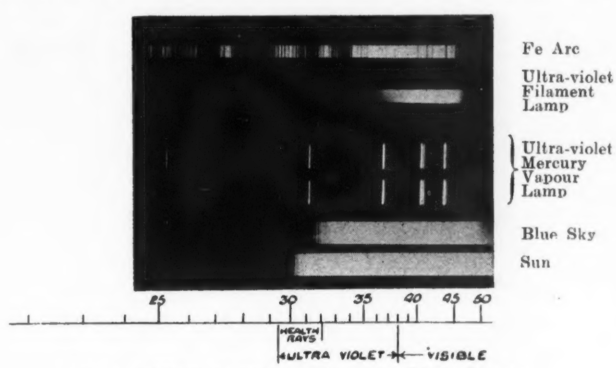


FIG. 6.—Spectra of various Ultra-violet Light Sources.

nation of a tungsten filament and a mercury-vapour arc between tungsten electrodes enclosed within an ultra-violet glass bulb. A diagram showing the arrangement of this lamp is shown in Fig. 7. A drop of mercury, which is enclosed within the bulb, gives off sufficient vapour to start an arc between the tungsten electrodes almost immediately after the current has been switched on. By combining the filament light with that of the arc the unpleasant colour of the mercury-arc light is somewhat reduced. Of course, this is a low-voltage lamp (35 volts starting—11 volts running), and requires a rather heavy current (30 amps.)

A third type of lamp, which it is claimed is quite safe for general use, and still gives sufficient ultra-violet to produce beneficial results, is a low-pressure mercury arc, enclosed within an opaque silica (vitreosil) tube, and shielded by an ultra-violet glass screen. For this lamp a special starter is required. Its emission is reproduced in the third band of Fig. 6. Fig. 6 is completed by the inclusion of bands 4 and 5, which show respectively the spectrum of blue and white sky and of direct sunlight (July).

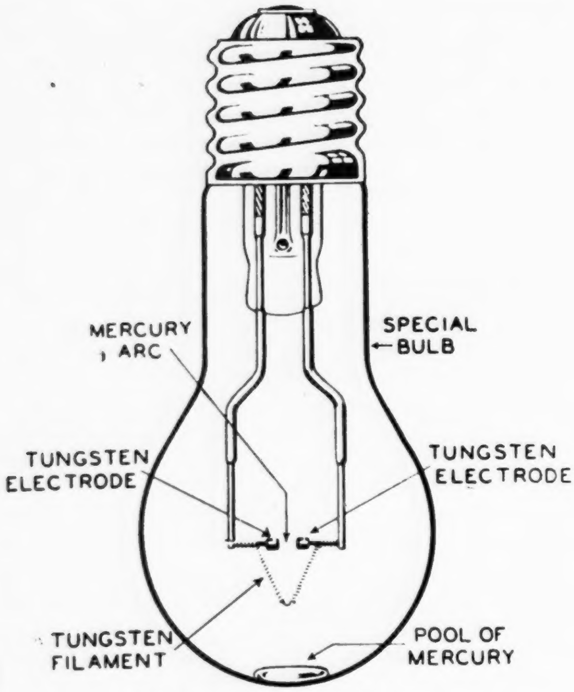


FIG. 7.—A New Ultra-violet Lamp.

Wood's Glass and Fluorescence.

During the early part of the war we were asked at the Department of Glass Technology at Sheffield to prepare a glass which was opaque to the visible rays but which would transmit the invisible ultra-violet rays. The glass was needed for experiments on invisible signalling. Glass of this type is known as Wood's glass —after its inventor, Professor Wood, of John Hopkins University—and owes its peculiar properties to the fact that it contains a certain proportion of nickel oxide on a potash base, which is sufficient to colour the glass very deep blue, and thus obstruct the passage of rays of visible light; but this colour does not obstruct the rays of shorter wavelength down to 310Mμ (Fig. 8.) By

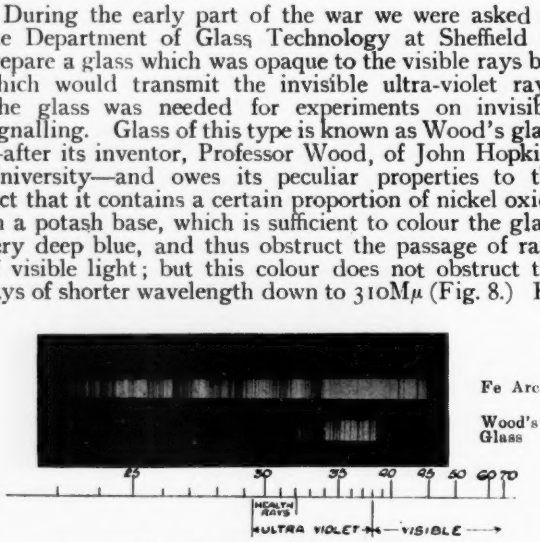


FIG. 8.—Ultra-violet Transmission of Wood's Glass.

the use of this glass it is possible to have a room in darkness but filled with invisible rays that only need suitable media for showing them up. The best way of showing the presence of ultra-violet rays is by using the property that certain substances have of converting these rays of very short wavelength into rays of longer wavelengths—so long that they extend into the range of visible rays. One such means has already been mentioned—namely, fluorescein solution in a silica vessel—but the illuminating engineer who may want to use this method of producing theatrical or stunt effects does not generally wish to go to the expense of clear silica ware, nor does he wish to rely on solutions. Fortunately, a glass is known which shows up these fluorescence effects very well indeed— it is sometimes spoken of as canary glass, because of its greenish-yellow colour. The constituent which bestows this fluorescent property on canary glass is uranium oxide. As small a proportion as 1 per cent. of this oxide on a soda-lime base gives a strongly fluorescent glass which has the power of transforming invisible ultra-violet rays into longer rays of green light. Certain other glasses show this property of fluorescence, but in such a small degree as to be useless to the illuminating engineer who is wanting unusual effects. There are, however, many substances which possess this property, and which may, if desired, be painted on to the inside of ultra-violet transmitting glass vessels. Such vessels, when under the influence of filtered ultra-violet rays, show up by the fluorescent coating. Owing to the different colours which can be obtained by such fluorescent coatings, many interesting effects can be produced in this way.

Besides its use for what may be called "stunt effects," Wood's glass has proved to be very valuable in research, for quite a number of things can be picked out under the influence of ultra-violet rays in the absence of visible light, e.g., hair from a scalp infected with ringworm shows a strong fluorescence under ultra-violet—hair free from infection does not—genuine pearls and many valuable stones may be distinguished from imitations; false teeth can be easily distinguished from natural ones; and even the end point of an acid-alkali titration can be determined by using the fluorescence of quinine as an indicator.

Still one other type of glass deserves mention, namely, that which has the property of transmitting the visible rays without appreciable selective absorption, but still shows a strong absorption in the ultra-violet. Such glasses with varying degrees of ultra-violet absorption have been developed on the basis of the pioneer work published in 1914 by Sir William Crookes, after whom they are named. Crookes showed that the oxide

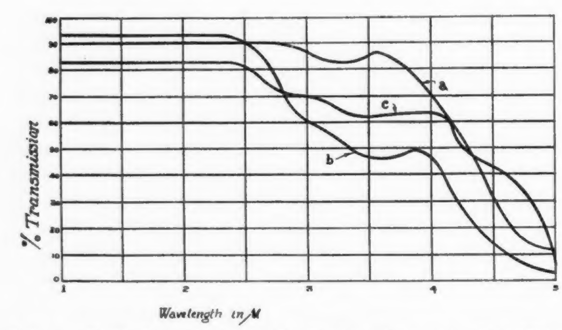


FIG. 9.—Heat Transmission: (*a*) Quartz Glass, (*b*) Soda-Silica Glass, (*c*) Soda-Lime-Silica Glass.

of cerium (ceria), when added to a glass, caused it to absorb the ultra-violet strongly. This oxide is still an essential constituent of all such glasses as are colourless or nearly colourless. Besides being used for spectacles, glasses of this character may find use in special cases where it is desired to prevent the fading of colours which are sensitive to ultra-violet light. If a coloured glass is not objected to, then an amber glass coloured by iron and manganese oxides is very efficient in absorbing ultra-violet rays right up to the end of the visible spectrum, i.e., up to 390Mμ to 400Mμ.

Glasses for Use with Infra-red Radiations.

On turning to the invisible infra-red or heat rays, extending from 780Mμ, or 0.78Mμ upwards, we again have three types of glasses: (1) for transmitting both visible and infra-red rays, (2) for absorbing infra-red but transmitting the visible rays, and (3) for transmitting the infra-red and absorbing the visible. Considering first the transmission of both light and heat rays, pure fused quartz in a thickness of only 1 mm. becomes opaque to these heat radiations at about 5μ, so that it is not to be expected that any glass containing, say, 70 to 75 per cent. of silica will show any better transparency—the reverse is to be expected and is found to be the case. If a better transparency to these rays is desired—as in the manufacture of certain scientific instruments—then recourse must be had to rock salt, which transmits up to or beyond 16μ.

Curves showing the transparencies of (*a*) quartz glass, (*b*) soda silica glass (18 per cent. Na_2O, 82 per cent. SiO_2), and (*c*) soda-lime-silica glass (18 per cent. Na_2O, 15 per cent. CaO, 67 per cent. SiO_2) are given in Fig. 9. These curves are taken from a

recently published paper by Schmidt, Gehlhoff and Thomas, and show that though both soda and lime reduce the heat transmission to a certain extent they are not very effective in this respect. Perhaps a better idea of the physical effect of this heat transparency may be obtained by measuring the radiation received by a thermopile from a very hot source, both with and without a sheet of glass interposed. In this way a practically colourless piece of sheet glass 2.5 mm. thick, and giving a light transmission of 90 per cent., gave a heat transmission of 88 per cent. when the clear sun was used as source and 80 per cent. when a 500-watt lamp was used.

The question of heat absorption was dealt with by Crookes in the same paper in which he dealt with ultra-violet absorption. Of all the various oxides that he tried, he found that iron oxide was by far the most effective for preventing the passage of heat rays. He also found that when the iron was in the ferrous or reduced condition it was much more effective than when in the ferric or more highly oxidized state. These observations have been confirmed by every investigator who has worked along similar lines, so that all the heat-absorbing glasses that are available to-day rely for their special properties on the presence of iron in the lower state of oxidation. The only essential difference between these glasses is the method that has been used in their manufacture to reduce the iron oxide to this ferrous condition, for it must be remembered that when a glass containing iron oxide is melted without any attempt to control the state of oxidation, then the two oxides—ferric and ferrous—are both present in a state of equilibrium. The colour of such a glass is the familiar green of the pre-war cheap bottle. When a deliberate attempt is made to keep as much of the iron as possible in the reduced condition the colour of the glass is blue-green, and, according to a suggestion made in a recent patent specification, if the whole of the iron were kept in the ferrous condition, then the glass would be pale blue. (There is some support for this view in the author's work on ultra-violet transparent glass.) In the manufacture of heat-absorbing glasses, Crookes' lead is often followed, for he found that the best way to introduce into the glass the iron and the necessary reducing agent was to add them together in the form of iron oxalate. This salt decomposes under the action of the heat of the furnace, and the iron oxide and its reducing agent are

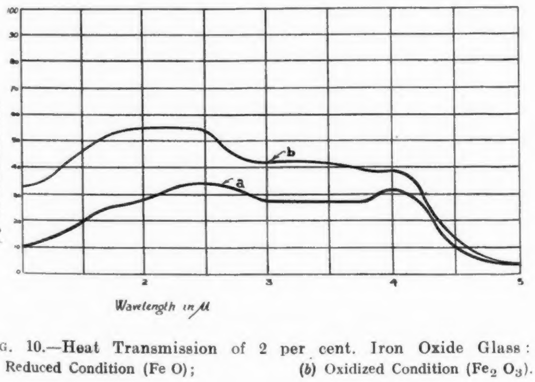


FIG. 10.—Heat Transmission of 2 per cent. Iron Oxide Glass: (a) Reduced Condition (Fe O); (b) Oxidized Condition (Fe_2O_3).

then formed separately, but in intimate contact. As with ultra-violet glasses, more recently non-organic reducing agents have been used with success. The influence of iron oxide and the difference between the ferric and ferrous states is shown in Fig. 10—these curves are again taken from the paper by Schmidt, Gehlhoff and Thomas.

The results of measurements with a thermopile, together with light transmission measurements for a number of commercial heat-absorbing glasses and two experimental glasses, are given in the accompanying table, a 500-watt lamp being used as the source.

Light Transmission and Heat Absorption of Various Glasses—2.5 to 3.0 mm. thick.

Glass	% Heat Absorption	% Light Transmission Red	Green	Blue
H. (Clear)	74	59	72	71
H. (Cathedral)	73	—	—	—
T. (Clear)	72	59	71	71
C. (Cathedral)	93	17	36	35
A. (Clear)	79	59	75	75
5. (Experimental	86	50	70	69
12. (Experimental)	93	25	45	44

These results are set out diagrammatically in Fig. 11,

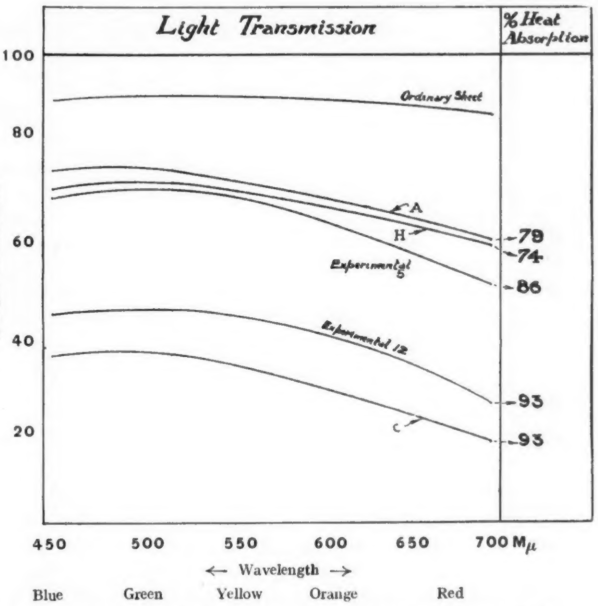


FIG. 11.—Light Transmission and Heat Absorption of Various Glasses.

which indicates that in general the strong heat absorption is accompanied by poor light transmission, but the two factors are not accurately proportional to one another.

Glasses of this type are of course of great value in the tropics, and even in this country too for roof lights, for by the use of such glass it is possible to have hot sunshine out-of-doors but keep the temperature indoors quite cool. Of course, the colour of the glass is not in its favour, but after spending a little time in a room or workshop glazed with such glass the colour is not noticed. In artificial illumination this type of glass finds a useful field, especially in those cases in which a high concentration of light is required without the ordinarily attendant heat—e.g., in certain types of hospital operating units.

As a last type of glass to be considered, there is a very interesting glass which has the power of absorbing all visible rays but transmitting infra-red rays. Such a glass, of course, appears black in thicknesses of 2 mm. and upwards, but in very thin sections it has a reddish amber colour. As a means of invisible signalling, this glass has almost, if not quite, superseded Wood's glass, since infra-red rays are easier to produce in quantity than ultra-violet rays, and they also have the great advantage of carrying further, as they are not easily absorbed by the atmosphere. For burglar alarms and apparatus of that type this glass has an interesting field of usefulness.

In conclusion, I would like to thank the following firms who have been good enough to loan apparatus for test and demonstration purposes, without which the presentation of this paper would have lost practically the whole of its interest: Messrs. A.E.G., Cambridge Scientific Instrument Co. Ltd., Chance Bros. & Co. Ltd., Edison Swan Ltd., Holophane Ltd., and Kelvin, Bottomley & Baird.

Glasses for Use with Invisible (Ultra-Violet and Infra-Red) Rays

DISCUSSION

Mr. F. W. HODKIN, B.Sc., F.I.C., after thanking the Secretary for inviting him for the third occasion to hear and discuss a lecture by Dr. English, said the lecturer had presented to the members of the Illuminating Engineering Society a paper of vital interest, and had concentrated the known data upon very complex problems in such a way as to render the subject informative and interesting. As Dr. English had mentioned, glasses for transmitting and absorbing invisible rays had received special attention during the last few years, which was largely due to the discovery and investigation of their therapeutic action, and also certain sources of artificial light.

While the firm of Schott, at Jena, had, some 25 or 30 years ago, produced glasses for stellar photography, the initiative in the more recent development of ultra-violet transmitting glass was due to an Englishman, Mr. F. E. Lamplough. Great advances had been made in the last five or six years in the technology and manufacture of such glasses. It was creditable to the Society that its members were interested in such developments, and appreciated that lighting was not merely a question of candle-power fittings, or decorative value.

Getting down to the details of the paper one met an old "friend" iron oxide—he called him a "friend," although Dr. English calls him an "enemy" and had mentioned that iron oxide and titania were the most troublesome constituents of glass for transmitting ultra-violet rays. Since every glass contains iron oxide and titania, due to the fact that it was usually melted in clay vessels, the lecturer's statement was, up to a point, correct; but there were other oxides which should also be avoided, such as those of lead, vanadium, cerium and antimony. Probably vanadium was the most potent agent if it was desired to obstruct ultra-violet light, but iron oxide was also a most troublesome agent. It is generally accepted that whatever iron was present in these glasses (and it should be avoided as far as possible) should be in the ferrous condition, as occurred when glasses were melted under reducing conditions. A process had, however, been patented by a well-known glass-making firm, involving the melting of such glass under oxidizing conditions. Glass with the iron oxide in the ferric condition was then obtained. The main idea of this patent was to get a glass which was not so subject to solarization, i.e., which did not lose so quickly its power of transmission of ultra-violet light. The proposed method of oxidation was by putting in potassium nitrate. Solarization was generally supposed to bring about a photo-chemical oxidation of ferrous oxide to ferric oxide. As soon as the iron was oxidized the ultra-violet transmission was reduced, but it could be restored by heating the glass, say, up to 400° C. He would like to know whether Dr. English considered that restoration of the ultra-violet transmitting power was due to reconversion of any ferric oxide into ferrous oxide? The speaker, however, did not think iron oxide was the only explanation: one firm was concerned about the question of gaseous oxides in glass. Mr. Hodkin also mentioned special forms of glass which did not solarize very quickly, or transmitted probably an exceptional proportion of ultra-violet energy.

Mr. Hodkin pointed out that in the case of glasses used for transmitting infra-red rays the iron oxide became a "friend." Dr. English seemed to be in some doubt as to the blue colour which was said to be obtained when iron oxide, in a reduced condition, was present in glass. On this point he (Mr. Hodkin) could afford some confirmation. Some years ago, when experimenting at Sheffield with carbon-sulphur amber glasses, it was found that when the glass was poured away there remained in the bottom of the pot a gorgeous sky-blue piece of glass. This seemed an extraordinary colour to get, and investigations as to the cause of it were made. Various reasons, such as the presence of colloidal sulphur, were suggested, but it was ultimately found that this blue colour only occurred in pots which were really bad ones, where there was a prevalence of "iron spots." Dr. English mentioned that Crookes introduced his iron as iron oxalate. People did use sugar and other carbonaceous materials in order to reduce the iron oxide to the ferrous condition—the only objection being that one might obtain a carbon amber, in which case zinc or tin oxides could be used to bring the colour back to a blue-green.

With regard to tungsten-filament lamps having bulbs of ultra-violet transmitting glass, it was generally understood that these lamps could produce "sunburn." It had been stated that one of these lamps used at a distance of 5 feet was as good as sunlight; they were used for heat therapy for curing rheumatoid arthritis. He (the speaker) would like to know whether Dr. English considered these lamps are really useful in that direction or whether they only produced a "hectic flush."

In regard to the artificial ageing of ultra-violet transmitting glasses by means of the mercury and quartz arc, would Dr. English say whether he considered this an adequate and proper test by which to judge their properties as regards solarization? Dr. English has said on one or two occasions that solarization was not complete in less than three to six months, whereas others thought that it was complete in a few days in bright sunlight.

Finally, in Dr. English's consideration of the spectrum he referred to certain "simple colours" which appear. He (the speaker) objected to such colours as orange, green or violet being called "simple"!

Mr. A. W. BEUTTELL said that illuminating engineers were interested in the use of glass for windows, in order to admit natural lights as well as artificial lighting appliances. There was no doubt that the question of allowing ultra-violet rays to enter our rooms would become a very important matter in the future. Mr. Beuttell referred to an article written from the south of France by a famous hygienist who remarked that he did not consider it necessary for English people to travel all the way to the south of France to enjoy the benefit of the sunlight: all that was needed was to build a ring of huge solariums round our coasts, fitted with high-power lamps for ultra-violet radiation, and sand and water for visitors to lie about in. Although such an idea might seem fantastic to-day, it was striking as a recognition of the beneficial effects of ultra-violet radiation and of the extension of "sun-lighting" in the future.

Speaking of the striking fluorescent colour-effects of certain minerals, etc., shown during the lecture, Mr. Beuttell recalled the fact that a famous expert in the lighting field, and an associate of Edison, Mr. W. J. Hammer, had shown him 23 years ago in New York a collection of beetles, etc., which he had painted with fluorescent matter and which produced very weird and wonderful effects; yet although Mr. Hammer had prophesied the use of this discovery for theatrical illumination and electrical signs, it could not be said that up to the present very great practical use had been made of it, and one had still to look to the future for its full employment.

The speaker asked Dr. English to explain what happened if special heat-absorbing glasses were continuously exposed to heat—did they go on absorbing heat until they melted, or was a state of equilibrium reached? If the glass did not transform the heat rays into shorter waves, presumably it absorbed them and became progressively hotter in the process.

Mr. J. S. DOW said that the fluorescence of objects under ultra-violet rays furnished a new means of analysis, which already had many unexpected applications. He understood that, apart from the detection of spurious precious stones from genuine ones, one could often obtain useful information, through fluorescence, as to the place of origin of gems and minerals. Invisible

rays had also enabled forgeries of old masters to be detected, and had revealed repairs and additions to furniture supposed to be genuinely antique.

An interesting application that had come under his (Mr. Dow's) notice was the use of ultra-violet rays in the study of rare postage stamps. Any stamp collectors present would know that an old imperforate stamp in fine condition might be very valuable, whereas if torn or having small margins it could be bought for a small sum. Hence, in the stamp trade, repairing was quite as usual as in the case of old furniture. Apparently perfect copies could be prepared by invisible mending; no join could be seen even by the microscope, though, in fact, the stamp might consist of portions of several stamps joined together. Under ultra-violet light the method of mending and joining up was often evident. Again, many quite common stamps became rare varieties if bearing a certain surcharge—hence the temptation to forge such surcharges. The forged surcharge might, to the eye, resemble the genuine one very closely; but in some cases the colour of fluorescence of the ink under ultra-violet light enabled the true to be distinguished from the false.

The complete ultra-violet cabinet equipped with mercury-vapour lamp, etc., was, however, somewhat expensive and unwieldy. Did Dr. English think that a compact and inexpensive apparatus using a gasfilled lamp with quartz bulb and sufficiently powerful to produce useful fluorescence effects could be produced?

Mr. Dow also remarked that in the ultra-violet cabinet a distinct though faint visible light was produced. If glass could be adopted which completely obscured all but the visible rays, relatively slight fluorescences could be detected; and as almost everything fluoresced to some extent, the range of analysis might be widened.

Finally, Mr. Dow recalled the experience that infra-red rays impinging on a phosphorescent object caused the luminosity to decay rapidly. Did the presence of heat rays have a similar effect in diminishing fluorescence? If so the complete elimination of heat rays, as well as visible rays, would seem to be a very desirable thing.

Mr. R. WALKER said that on his journey to London he had been accompanied by a gentleman who was bringing back a number of blind children from one of the homes in Torquay. He (Mr. Walker) had introduced this gentleman to Dr. English and had induced him to come to the meeting, as he was much interested in the effects of ultra-violet rays.

Mr. Walker added that he had been brought up with the idea that the human eye worked best under daylight conditions. He had, therefore, been surprised to read in advertisements statements that the light from certain artificial illuminants was better to see by—notwithstanding the fact that they differed from sunlight in emitting an excess of infra-red rays.

In conclusion the speaker emphasized the importance to architects of receiving definite and accurate information which they could easily apply. If the Society could provide data of this description the work of the architects would be aided considerably.

Mr. R. E. BARTON remarked that in the experiments with ultra-violet light which the author had shown he had made use exclusively of direct light. He would like to know how far ultra-violet rays could be reflected in the same manner as visible light, and what kind of surface could best be used for the reflection of such rays?

Mr. A. CUNNINGTON (*communicated*).—An example of the application of ultra-violet light to advertisement lighting is seen in certain posters that have been specially dealt with on the Southern Railway at Waterloo Station (main line booking hall) and elsewhere. Perhaps it is not strictly correct to call this "ultra-violet" lighting, as the effect is not obtained entirely by invisible rays, but at any rate the illumination is produced by light confined to the extreme violet end of the spectrum, and this light impinging on special pigments in the poster produces a striking luminous effect. The poster gives the impression of being transparent and illuminated from behind, whereas in reality the light is given by a screened fitting fixed in the form of a bracket above the top line of the poster. It is understood that the source of light is a mercury-vapour lamp, and that the rays from this are passed through a special screen to limit further the wavelengths. Possibly Dr. English will be able to give more accurate details.

Dr. WM. HAMPTON (*communicated*): I have read with considerable interest Dr. English's typically able paper, and regret that I was unable to be present when it was delivered. One gets into the habit of looking forward to Dr. English's annual summary relating to glass, in the *Illuminating Engineer*, and trusts that he will be able to keep this feature going for some time.

As the firm with whom I am associated are makers of most of the special types of glass to which reference is made by Dr. English, I was particularly interested in

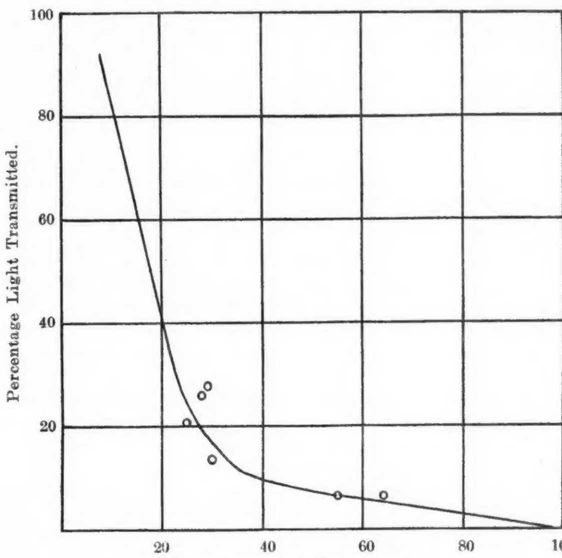


FIG. 1.—Curve showing the Relation between Light and Heat Transmissions of Heat-absorbing Glass for Gasfilled Lamps.

the summary of properties in various part of the spectrum which constitutes the chief value of the paper. The matter I found of most interest was that relating to the heat-absorbing glasses, which are shown diagrammatically in Fig. 11. I find, personally, that it is difficult to visualize whether or not an improvement has taken place from simple statements of figures, and, in order to assess the value of a change, we have found that the use of a diagram such as I give above (Fig. 1) is of considerable assistance. This diagram shows the relation between light and heat transmissions for any given source for heat-absorbing glass, such as we have had on a commercial scale for some years. It shows in essence the way in which these two quantities vary when either the thickness of the glass is changed with a given concentration of absorbing material, or, alternatively,

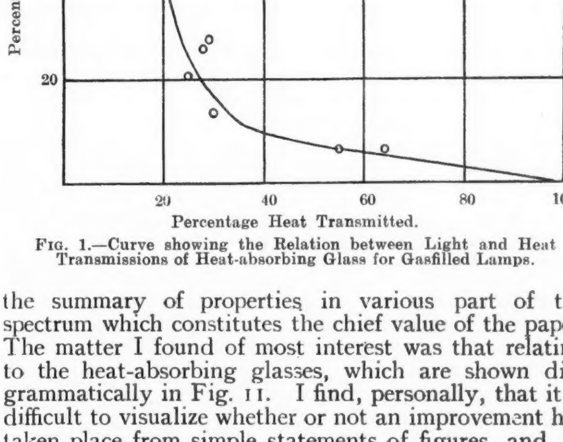


FIG. 2.—Light Transmission Curves for Heat-absorbing Glass.

the way the transmission changes for a glass of constant thickness with varying amounts of absorbing material. The actual diagram shown refers to the heat and light from a high-efficiency gasfilled electric lamp, such as was used by Dr. English in his measurements. Any new glass which is made can be plotted on this diagram, and it is immediately seen whether or not an improvement has been made. The circles on the diagram show the glasses given in Dr. English's table, and it is seen that two of these are appreciably better than normally manufactured commercial glasses, while some are substantially worse. Some slight variation is, of course, inevitable in any manufacturing process, but the use of this diagram allows a rapid comparison to be made.

The other diagram given (Fig. 2) shows the transmission curve for the particular glass from which the first figure was constructed. This is, of course, on the same basis as Fig. 11 in the paper, but there is a definite indication that the glass which I have used is substantially bluer than those made by Dr. English. In case there is any suspicion that there may be some experimental error in the curve I quote, I may say that it was determined by the National Physical Laboratory.

Author's Reply

Dr. S. ENGLISH, in replying to this discussion, said he was pleased to see Mr Hodkin at the meeting again, and to hear his contribution to the subject under discussion. Confining himself to answering the questions that had been raised, Dr. English said that he was well aware of the patent which had been taken out by a well-known glassmaking firm for melting ultra-violet transmitting glass under oxidizing conditions, with a view to minimizing solarization when the glass was put into service. When he was experimenting on this subject as far back as 1927, he had carried out similar experiments himself, and had produced glasses of the same chemical composition, except that some were melted under oxidizing conditions, and others under reducing conditions. Those melted under reducing conditions had, when new, a distinctly better ultra-violet transparency than those melted under oxidizing conditions. After artificial ageing with a mercury-arc lamp, those melted under oxidizing conditions showed practically no reduction in transparency. Those melted under reducing conditions showed a distinct reduction in ultra-violet transparency, but still they were better than those melted under oxidizing conditions. (A slide was shown on the screen illustrating this point.) He was therefore of the opinion that though melting under oxidizing conditions does reduce the solarization, it is nevertheless commercially useless, as the glasses melted under reducing conditions have, after solarization, always retained a better transparency than the chemically oxidized glasses.

It was perfectly true that glasses which had been solarized naturally, or aged artificially, could be rejuvenated by heating them to their annealing temperatures. This was discussed by the author in a paper published in *Glass* in the autumn of 1928, and there the view was taken that the loss of ultra-violet transparency on ageing, and the rejuvenation on reheating, was due to the change-over of some of the iron oxide in the glass from the ferrous to the ferric condition and vice versa. It was pointed out that this phenomenon was very similar to the development of a purple colour in ordinary decolourized glasses when exposed to the sun and the removal of this purple colour by reheating to the annealing temperature.

Dr. English said he was glad to have Mr. Hodkin's reminder of the blue colour which was produced in certain pots in which carbon-sulphur amber glasses had been melted. He only expressed doubt concerning the possibility that a completely reduced iron oxide glass would have a blue colour, because the general impression was that ferrous oxide gave rise to a green colour in glass, and before one could say that this was not the case one needed to have very good grounds and numerous examples to back up one's opinion.

Regarding the use of tungsten-filament lamps in ultra-violet ray transmitting glass bulbs, Dr. English said that he had not yet had any experience of their efficiency in producing an erythema, but from the spectrum photographs which he had obtained there was no doubt that these lamps did produce distinctly more ultra-violet than the ordinary gasfilled lamp. For further information on this point he would have to refer Mr. Hodkin to such medical publications as the *Journal of Actinotherapy*.

In his remarks concerning artificial and natural ageing of glass, Mr. Hodkin has touched a very thorny subject, and one on which perfect agreement had not yet been reached. The author maintained that with a mercury arc artificial ageing of ultra-violet glass, if not carried on for too long (say five hours), was a very satisfactory means of testing glass to see how it would behave when exposed to the sun. Glasses which behaved satisfactorily in this test behaved satisfactorily when they were exposed to the sun. Regarding the period during which deterioration, due to the effect of sunlight, proceeds, the author put forward in the previously mentioned paper many photographs showing that this deterioration proceeds rapidly during the first month or two of exposure, and gradually slows down, reach- a stable stage after about four, five or six months, according to the nature of the glass and the brilliancy of the sun to which the glass was exposed. He was well aware that others maintained that solarization was complete in a few days or a few weeks, but he was confirmed in his own opinion by a recent publication of the "Bureau of Standards," which showed that solarization was not perfectly complete even after several months' exposure. He would, however, like to emphasize the fact that this solarization did reach a definite limit, and that after a certain period of several months the glass did reach a perfectly stable condition, after which no further loss of ultra-violet transparency occurred. He would also like to correct the impression that some people had spread about, by saying that even completely solarized samples of good ultra-violet glasses still had ultra-violet transparencies of 50 per cent. to 60 per cent., or even more, in the important health-ray zone.

Replying to Mr. Beuttell, Dr. English said that he was pleased to hear that an English Riviera had been envisaged by the building of solariums fitted with ultra-violet lamps and provided with sand and water. This was not quite such a dream as it may appear at first sight, for one of the ultra-violet lamps (of which the spectrum photograph was shown in the paper) was actually developed in a solarium attached to one of the large hotels on the South Coast. This solarium, fitted with two or three of these lamps, is now an attractive and popular feature of this hotel.

Mr. Beuttell's suggestion that heat-absorbing glass, when exposed to heat, became distinctly hot, was perfectly true, but even long exposure would never raise the temperature of such glass to anywhere near its melting point. An equilibrium was reached, and the absorbed heat appeared to be dissipated in radiations of longer wavelengths.

Dr. English was much interested to hear Mr. Dow's contribution concerning the use of filtered ultra-violet light, in directions which were not previously known to him. The suggestion that Mr. Dow put forward, that a fluorescence cabinet fitted with a quartz bulb and high-efficiency gasfilled lamp would be more compact and less expensive than the fluorescence cabinet which was shown, was certainly one that should be investigated. He was unable to say whether such a lamp would give sufficient ultra-violet for this purpose, but in view of the fact that this fluorescence was produced by the rays extending up to the limit of the visible spectrum, there was every reason to expect that such lamps would produce sufficient of these rays to permit of their being used satisfactorily in such a cabinet. The sample of Wood's glass which was used in the cabinet for demonstration purposes certainly did let through some of the visible rays in the extreme violet, but by using a sample of glass rather thicker than the one in the cabinet, it was possible to eliminate altogether these visible rays.

It is perfectly true, as Mr. Dow suggested, that heat rays tended to destroy the fluorescence produced by ultra-violet rays, but in the ordinary fluorescence cabinet the ultra-violet rays were so very much more powerful than the heat rays that the latter were of little or no importance in diminishing the fluorescence shown by most materials. If all heat rays were completely eliminated, one might be able to obtain effects which are not now possible.

Replying to Mr. Barton, Dr. English stated that ultra-violet rays could be reflected in a manner similar to the reflection of visible light, but the materials used for the reflector might have to be different. One of the best reflectors of ultra-violet rays was aluminium. Chromium-plated reflectors were also fairly satisfactory.

Added: I am pleased to read Mr. Cunnington's communicated contribution to the discussion concerning the use of filtered ultra-violet light in enhancing the appeal of advertising posters. I am not familiar with the particular installation to which Mr. Cunnington refers, but from his description it appears quite certain that the striking luminous effect is due to the action of ultra-violet light on fluorescent pigments, which have been used in preparing the design, and is therefore in principle very similar to the fluorescence cabinet which was used to illustrate the paper. Of course, for the most effective use of such posters, it would be advisable to have them placed in comparatively dark corners or surroundings, so as to imitate as far as possible the conditions used in the fluorescence cabinet.

I much regret that Mr. Hampton was not able to be present at the meeting when the paper was presented, for he always makes a valuable contribution to such papers. Mr. Hampton's communicated contribution is none the less welcomed, for it contains excellent suggestions for the portrayal of the two chief characteristics of glasses which are used for heat absorption. The diagram which Mr. Hampton uses is a very much better one than that which is used in the paper in Fig. 11; in future, the author will certainly use a diagram of this type in his own work on this subject. It is interesting to note that Mr. Hampton agrees that two of the glasses, results for which were given in the paper, are rather better than the ordinary commercial heat-absorbing glass, and that others are distinctly less satisfactory.

A New Arc-Source of Ultra-Violet Light

In the *Journal* of the American Institute of Electrical Engineers for December, 1930, Mr. W. C. Kalb gives a description of a new type of arc lamp, which is stated to furnish an exceptionally powerful source of ultra-violet energy. The lamp, illustrated in the original article, uses duplicate pairs of carbons 12 inches long, each pair being used alternately at intervals of about half an hour. A single pair will burn for 12 hours if operated on 45 amperes., or for eight hours on 90 amperes. Panels of glass pervious to ultra-violet energy enclose the arc, but these may be removed when very short-wave radiation is desired. The lamp is ordinarily equipped with cerium-cored carbons, and is stated to give a spectrum closely resembling that of sunlight. With a current of 60 amperes it furnishes about 30,000 candles, and the ultra-violet energy at a distance of six feet is equal to that of average sunlight. If carbons cored with a composition of iron, nickel and aluminium be used, the lamp becomes very much richer in ultra-violet.

It is suggested that this new source will encourage the application of light to various industrial processes. Amongst other applications mentioned are the irradiation of food products, stock, poultry feed and other organic products, and the use of the ultra-violet radiation furnished as a chemical drying agent.

The Lighting of Coal Mines

In the course of a discussion on accidents in mines, which took place in the House of Commons, Mr. Shinwell, the Secretary for Mines, made an important statement in regard to measures for securing more efficient lighting in mines.

"We have," he said, "succeeded in taking a definite step in one particular direction. I refer to more efficient illumination in the pits, and I approach this aspect of the subject by making particular reference to that most painful disease, prevalent in the industry, called nystagmus. About the facts I shall not speak, but so far as research has gone, although there is a difference of opinion, it is generally agreed that nystagmus cases are attributable to deficient lighting. It has been suggested that to some extent they may be due to the stooping posture adopted by miners, and the gassy condition of the pits. That may be so; but the bulk of scientific opinion on this subject holds the view that inefficient lighting is the primary cause. Therefore we are devoting some attention to the question of better illumination, and I want to read to the House very shortly—and I take this opportunity of making the announcement for the first time—a summary of the Draft Order that we propose to submit to the industry for their discussion and we hope for their endorsement."

Mr. Shinwell then proceeded to give fuller details of the new measures, as follows:—

"These new proposals in relation to mine lighting aim at a general improvement in the standard of lighting in three principal directions. First of all, there is the raising of the minimum candle-power standard in miners' safety lamps—not only the flame lamp, but the electric lamp as well. Then we propose to provide a relaxation in the present drastic statutory restriction upon methods of lighting other than safety lamps. That is a subject that is full of difficulties, because there is, as everybody familiar with mining is aware, a dispute as to whether the use of electricity in the pits is desirable, and I am speaking of electric lighting. Then we propose to secure, if we can, definite provision for a reasonable standard of surface lighting, which hitherto has not been regulated by law, except for railway shunting operations.

I have not the time to give the figures now, but we are faced with a considerable number of accidents and fatalities on the surface, many of them due, no doubt, to faulty lighting. We propose to proceed at once with this Draft, and to submit it to the industry, hoping for their consent and support, not only with a view to dealing with the accidents that are due to faulty lighting on the surface, at the coal face, and on the main roads in the mines of this country, but also with a view to making a definite attack on the problem of nystagmus; and I hope we shall receive, when the matter comes before both sides of the industry, a very large measure of support."

We understand that this work is already proceeding, and the exact nature of the new proposals will be awaited with general interest.

The Lighting of Railway Crossings

We notice that the lighting committees of the Pacific Coast Electrical Association have decided this year to concentrate their efforts on improving the lighting of railway crossings. In the United States dangers at such spots are possibly greater than in this country, though perhaps not so serious as in some Continental countries, where the frequency of accidents has led to special warning devices. But even in this country, where level crossings are comparatively infrequent, the danger is a real one, especially in view of the continually increasing traffic by night. There have, within recent years, been several serious accidents through motor coaches failing to observe level crossings in time, and the need for distinctive lighting and warning signals is a real one.

The Lighting of Offices and Public Buildings

(Mr. J. A. Macintyre's reply to the discussion of his paper on the above subject, which was read before the Illuminating Engineering Society on November 14th: See "Illuminating Engineer," December, 1930, pp. 290-292: January, 1931, pp. 7-11.)

Mr. P. J. WALDRAM considered that the criticisms of the daylight planning of buildings in London was based upon defects in some offices in Whitehall. While some of these offices are certainly bad in this respect, there are many others of comparatively recent design in which heavy ornament lowers the daylighting efficiency of good rooms to an extent which can hardly be justified, and in which the light wells provided are wholly inadequate to act as such. Mr. Good referred to examples in office buildings overlooking St. James's Park, and there are other examples in Kingsway and elsewhere.

In fairness to the official architects, it should be pointed out that the Whitehall offices in question were designed by a private architect, and not by any Government department.

As far as light-well areas are concerned, the architect can never have a free hand where land is expensive, as, on a site of any size, a client would not be prepared to make the sacrifice of floor area necessary to have all rooms lit adequately by day. It was never questioned that architects must make adequate fenestration one of the main factors in their design, but they are rarely in the happy position of being able to sacrifice everything else to having the ideal of natural lighting. Certainly until a few years ago the illumination part of their design work consisted of sizing the windows in accordance with a few empirical rules, and even the areas of the working planes which were behind the no-sky line were never worked out, much less the daylight factors.

It is largely due to Mr. Waldram's own work that more attention is being paid to this important matter to-day, but the design of some buildings, even of recent date, cannot but lead us to think that either the lighting efficiency has never been worked out on any sound basis, or else the client has forced the architect to give greater floor area than can be adequately lit by normal means, with the result that the occupiers of the rooms have to suffer.

The point was stressed in the paper with a view to inducing illuminating engineers, as well as architects, to give more attention to natural lighting, as no form of artificial lighting has ever been found to be quite a satisfactory substitute.

The small discrepancy in the figures quoted relative to the size of the light well in the case illustrated was due to dimensions being taken off two sets of plans to different scales, which varied slightly, but this discrepancy does not in any way affect the argument. In many cases the open light well is certainly better from the point of view of illumination design, but the obvious difficulty which the architect has to face with this is that all walls are exposed to the streets, and in a stone-fronted building the design may be very expensive. This, in fact, illustrates the point that the architect is rarely in a position to give the best lighting possible on the site at his disposal.

Mr. Waldram mentions the new Underground Railway offices, near St. James's Park, as an example of offices deliberately planned for daylight, and in this also we have an example of more attention being given to ornament than to sound planning, as, compared with the few who have realized how adequately the lighting problems in this difficult situation have been handled, there are very many who have very definite opinions on the Epstein figures which have been placed on the exposed walls!

The question raised by Mr. Beuttell as to reflection from light-well surfaces is dealt with fairly fully in Illumination Research Technical Paper No. 11, published by the Stationery Office. As he points out, the light which falls on the bottom of a light well is lost, unless there is a basement below fitted with roof lights. To keep this bottom surface white in a smoky city is impossible, and the author knows of no case where attempts have been made to reflect this light into the rooms by means of mirrors on a large scale. Individual room reflectors fitted to the windows are common enough, but these are usually placed after the building is finished, and are not a part of the structure. If Mr. Beuttell's suggestion were followed, and large pyramids of mirrors, each properly set to deal with individual rooms, were fitted in the base of deep wells, we should have to abandon the no-sky contour as the line of demarcation between adequacy and inadequacy, and the suggestion is by no means impracticable. Such mirrors could be kept clean enough by weekly hosing and rubbing down, perhaps once in six months or so, and if embodied in the original design as part of the structure it is quite probable that their cost would be more than compensated for by the enhanced value of the rooms they serve.

To get full value from such mirrors there should also be good internal reflecting surfaces, probably also capable of a fair amount of specular reflection, to get the light in the direction required without undue loss. Actually, to get the full value, these inside surfaces should be very much bigger than the outside mirrors feeding them, as the beam of sky thrown through the window will be much greater in cross-section than the mirror itself, if plane mirrors are used, but practically it is impossible to get anything like this full value. It was for this reason that so many small mirrors were used for Sir James Guthrie's picture.

This leads directly to the point made by Mr. H. Robertson that windows ought to start at the edge of a room. Neither the widening of a window nor alteration in its lateral position will throw the no-sky-line contour further back, appreciably, in the normal case where outside obstruction is more or less symmetrical, but, as Mr. Robertson points out, this may affect the light in the room materially where the surface of the wall has an important reflecting value. The fitting of wide windows, as he suggests, improving the reflection values of the walls and ceiling, or large areas of them, and flooding light on to these areas by reflectors are instances of method of improvement on average practice which might affect such difference as to be worth adopting as standard design.

The double fitting referred to by Mr. Robertson, in which light is thrown by one lamp or set of lamps and reflectors on to the ceiling, and by another set downwards, gives a pleasing effect, and can be very efficient. The maximum of efficiency is obtained when the illumination from the inverted system is just sufficient to remove the gloomy effect from the upper portion of the room, or to illuminate the ceiling, if this has some architectural value, leaving the lower portions of the fitting to give the working intensity. The arrangement gives more latitude in design and control than can be obtained by adopting semi-indirect fittings. The intensities recommended for ordinary clerical work by the Advisory Committee on the Lighting of Public Buildings were considered by Mr. Blok, Mr. Long, Mr. Jones and Capt. Halstead Hanby as being too low. The recommendation was that there should be an average of 3 foot-candles at mid-period of decoration and lamp life, a minimum average of 2.5 foot-candles, and that at no point on the working plane should the minimum be less than 2 foot-candles, and the author stated that there was no evidence, either from the point of view of health or output, that appears to justify higher figures than these.

In the first place, it should be pointed out that the recommendation is for rooms in which ordinary clerical work is done, and is not applicable to drawing offices, nor to the kind of work referred to by Mr. Blok as being done at the Patent Office.

Mr. Jones refers to Dr. Hartridge's tests on visual acuity. In the summary of conclusions of the Banister-Hartridge-Lythgoe tests, it is stated that "while artificial illumination of 2 to 4 foot-candles is most probably adequate for a variety of purposes, our results, which agree closely with those of Koenig, indicate that only about one half of the full acuity of the eye is achieved at these intensities. For the maximum acuity an intensity of 100 to 200 foot-candles is necessary."

This simply indicates that the wing of a night moth, or the detail of an elaborate Dutch picture, can be seen better under an illumination intensity of 100 foot-candles than it can under an intensity of 3, but the higher intensity is certaintly bad for the moth and for the picture. Adequate intensity for ordinary clerical work cannot be related to that required for fine work; its definition as the intensity at which the subject can carry on without appreciable eye effort must be accepted. Long and wide experience has shown that at the present day the figures quoted by the Advisory Committee still come within this definition. The present tendency to give higher values in shops, and certain commercial offices and showrooms, may, by contrast, force the figure up, but, in my experience, there is no improvement in output when this is done in ordinary offices. In the last generation a good standard was 1 foot-candle, and the question to which we can get no definite answer is: Are our eyes better now than then, or, in the American States and elsewhere, where such high figures are quoted, is there less eye trouble than in other places where people are content with lower standards?

In the vicinity of the intensity which is just adequate the appreciation of change is much greater than when a greater amount of light is given. Thus the effect of a change from 1 to 2 foot-candles cannot again be produced by a further rise to 3, but is probably the same as a change from 2 to 4, and again from 4 to 8, etc. This in itself promotes a tendency to give intensities higher than necessary when it is desired to have a margin of safety. In a day-lit interior we can work comfortably with intensities varying from 2 to 100 foot-candles, and the adequacy figure in this case is certainly in the vicinity of 2—probably a little less—for clerical work. The comparison of daylight and artificial light is dealt with later under reply to Capt. Halstead Hanby.

In the United States Public Health Bulletin No. 140, referred to by Mr. Long, the investigators who conducted the tests on letter sorting stated that "circumstances over which they had no control limited the number and character of the tests," and in the report it is stated: "No definite conclusions can be derived from the results of the tests, but it is felt that because of their evident consistency the data presented in Table XXIX are of value in indicating the trend of these tests." Special cards were used in the tests, and actually when the illumination intensity was lowered to 2.8 foot-candles at the end of the period there was no appreciable difference between the output at this intensity and that at an intensity of 3.6 foot-candles, the higher output being given at the lower figure when all groups of subjects were taken, and the difference between output at 2.8 foot-candles in the second test and that at 8 and 14 foot-candles was less than 5 per cent. overall. That at 8 foot-candles was slightly greater than that at 14. As was clearly the opinion of the investigators, the tests were of too short duration, and there were variable factors other than illumination. Little importance can be attached to the error quotations, as the main sources of errors in letter sorting are not due to faulty reading of addresses, except when the illumination is extremely low or the writing very bad. The investigators' attempts to eliminate the effects of these other sources were somewhat ingenious but not convincing.

It is a most difficult matter to deduce from tests of this nature what the output will be in actual practice over long periods, and for this reason the author refrained from quoting a reference in Illumination Research Paper No. 10 on "The Effect of Distribution and Colour on the Suitability of Lighting for Clerical Work" to the effect that "the actual intensity of illumination between 1 and 4 foot-candles did not appear to produce very much effect, at any rate for the artificial-daylight colour."

Letter sorting may not be ordinary clerical work, but it should not require very much higher intensity, and long experience in the British Post Office has actually indicated that values ranging from 3 to 4 foot-candles are adequate to-day, and the Post Office authorities have no reason to think that the eyesight of the sorters is subjected to any undue strain, nor that the output would increase if the intensity were raised.

The most convincing test on the effect of illumination intensity in fine work is perhaps that conducted by Mr. H. C. Weston and Mr. A. K. Taylor on "Typesetting by Hand," referred to by Mr. Long. The report on this is published by H.M. Stationery Office, and it indicates that the output increased and errors diminished up to an intensity of 20 foot-candles for this class of work.

In this we have a process which requires greater eye effort than ordinary reading or writing, and it would be equally wrong to apply the results of a test on this process to clerical work, as it would be to deduce from Dr. Hartridge's tests that 100 to 200 foot-candles was required.

In processes where output cannot be measured we have no dog to cross the bridge first—quoting from Capt. Halstead Hanby—but we must try it on ourselves, and judge by experience. In most drawing offices, and for work such as is referred to by Mr. Blok, about 8 foot-candles is required by the average individual, and the same figure applies to measuring processes on scales not too finely divided—such as 10-in. slide-rule work. The tendency to give this and higher intensities in commercial offices is due more to a desire to give an impression of prosperity on the part of the firm—and the same applies in the case of shop lighting—than to any definite opinion that output is thereby increased or employees suffer less eyestrain. There is no question that such increase produces this impression, and, as stated above, contrast leads to the demand for increase, even where such impression is of no value.

The 4 foot-candles at the Ministry of Pensions building referred to by Mr. Long had fallen to less than 2 in many parts, due to dust and obstructions, and the new fittings will just bring the illumination within the recommendation with rather poorer distribution than was given by the old.

Capt. Halstead Hanby stated that "for equal illumination visual acuity by daylight and artificial light were in the proportion of two to one." The author has certainly found that clerks will work contentedly in parts of rooms where the daylight intensity on the working plane is as low as 1 foot-candle over long periods. This they will do all day and every day, but immediately artificial light has to be resorted to they demand a higher intensity. Partial correction of this artificial light rarely makes any difference in the intensity demanded, and the reason for the higher demand is probably based on the fact that the user can judge more accurately from examination of the actual source of light that it is not up to the intensity which is commonly adopted. In the tests reported in Technical Paper No. 10 it was probably the "novelty" effect of the artificial daylight which kept the subjects from complaining at 1 foot-candle.

Mr. Young suggested top lighting for pictures, and undoubtedly this is nearly always the best form. Where circumstances demand that a picture be lit partly by daylight and partly by artificial at the same time some correction of the latter is usually beneficial, but generally there appears to be no sound argument for correction otherwise, when the colouring on the picture is normal.

Mr. Jones indirectly calls attention to one of the main difficulties in dealing with picture galleries, namely, that of getting an arrangement of fittings which will comply with the obvious requirement—namely, light the pictures adequately, and have low intensity on objects likely to be reflected—and at the same time be in keeping with the architecture of the room, to be inoffensive, especially by day. In existing galleries especially the difficulty is apparent, and unfortunately no gallery designed specially to eliminate it, either here or in the United States, has been accepted as quite satisfactory generally by artists, architects and engineers alike.

There is no question that gas lighting, as referred to by Mr. Minchin, can be quite satisfactory.

Mr. Simon refers to a system of individual lighting specially suited for drawing office and typists' work, using an adjustable fitting on the chair or bench, and thereby getting rid of ceiling flexibles. Such fittings have been found extremely popular and are very effective, but unfortunately some charwomen appear to have a desire to find out how much water a floor-plug fitting will hold, and where the plugs are in the skirting a little rough-and-tumble game at lunch-time in a large office often plays havoc with the leads! It is for this reason that it has been found advisable to limit the supply of table lamps to rooms occupied only by one or two individuals. To feed such fittings from ceiling points results in the same forest of flexibles as the use of ordinary pendants.

The author takes this opportunity of thanking members of the Society who were present at the meeting for the patient hearing given to the paper, and especially those who took part in the discussion.

Recent Developments in Gas Lighting

(Proceedings at the Meeting of the Illuminating Engineering Society held in the Board Room at 28, *Grosvenor Gardens, London, S.W.*1, *on Monday, January* 12*th,* 1931.)

By the courtesy of the British Commercial Gas Association, a meeting of the Illuminating Engineering Society was held in the Board Room at 28, Grosvenor Gardens, London, S.W.1, on Monday, Jan. 12th, 1931. Members assembled for light refreshments at 6-30 p.m., and the chair was taken by the President at 7 p.m.

Formal General Meeting.

The President explained that in order to comply with the Articles of the Society, which had now been registered as an incorporated body, a formal general meeting had to be held.

For the moment all he need do was to announce that the Society had been duly registered as an incorporated body on November 24th, 1930. In accordance with the customary arrangement any Corporate Member could obtain from the Hon. Secretary a copy of the book containing the Memorandum, Articles and By-laws on payment of a nominal fee of 1s.

New Members.

The minutes of the last session meeting having been taken as read the Hon. Secretary presented the names of the following applicants for membership:—

Armitage, G. H.......... Electrical Engineer, Springvale Electrical Co., Masbro Road, Kensington, London, W.14.

Barlow, H. S............. Lecturer in Physics, Illumination, etc., at The Northampton Polytechnic Institute, 38, Claremont Square, London, N.1.

Christopher, J. G....... Lighting Engineer, Underground Railways, Ltd., 26, Veronica Road, London, S.W.17.

Cotterill, H. M.......... Electrical Engineer, Research Laboratories of the General Electric Co., Wembley.

Lovell, G.................... Works Director to Robinson King & Co., 6, Exeter Gardens, Ilford, Essex.

Mason, W. M............. British Commercial Gas Association, 28, Grosvenor Gardens, London, S.W.1.

Wadey, W. A.......... Illuminating Engineering Department, British General Electric Co., Ltd., Clarence Street, Sydney, Australia.

Walker, J. C............. British Commercial Gas Association, 28, Grosvenor Gardens, London, S.W.1.

Country Members.

Sandys, G. H............. Lecturer in Electrical Engineering and Technology, P.O. Box 201, East London, C. P., South Africa.

Moir, G. H................ Electrical Engineer, General Electric Co. Ltd., Magnet House, Queen Street, Belfast.

Saeed, S. M............. The Maclagan Engineering College (Student), 18, B. Hostel, Lahore, India.

The names of applicants presented at the last meeting were read again and these gentlemen were formally declared members of the Society*

Mr. Oughton's Paper.

The President then called upon Mr. E. L. Oughton to read his paper on "Recent Developments in Gas Lighting." The paper was illustrated by a considerable number of lantern slides and by a representative series of fittings of modern design. The latter were described in detail, attention being drawn to the manner in which methods involving the scientific direction of light were now being applied to gas lighting. The lecturer illustrated the advantages of the "positive" and other forms of gas switches and dealt in turn with such problems as the lighting of churches and public halls, shops, factories and streets. In connection with public lighting special reference was made to the use of prismatic glass refractors for street lamps equipped with gas lighting.

The paper led to an interesting discussion in which the following took part: Mr. W. M. Mason, Mr. Haydn T. Harrison, Dr. J. W. T. Walsh, Mr. A. Cunnington, Dr. S. English, Mr. L. T. Minchin, Mr. J. S. Dow, Mr. G. Campbell, Mr. A. W. Beuttell, Mr. C. E. Greenslade and Mr. J. C. Walker. There was an exceptionally large and representative gathering, amongst others who attended being Sir Francis Goodenough, who, however, was called away before the discussion opened.

After Mr. Oughton had briefly replied to the discussion, he was accorded an enthusiastic vote of thanks on the proposal of the President who also thanked the British Commercial Gas Association for their hospitality.

Forthcoming Events.

In conclusion members were reminded that the **Annual Dinner** is to be held at the Trocadero Restaurant, on **Tuesday, February 10th,** at 7 p.m. for 7-30 p.m. The President expressed the hope that all members would make a special effort to attend.

It was announced that the **Next Meeting** of the Illuminating Engineering Society would be held at the Home Office Industrial Museum, Horseferry Road, Westminster, S. W., on **Wednesday, February 18th,** at 6-30 p.m., when there will be a discussion on **"Problems in Illuminating Engineering."**

* *The Illuminating Engineer*, January 1931, p. 5.

The Light Distribution of Airway Beacons

By H. N. GREEN*

A STUDY of the characteristics of airway beacons which have been installed in this and other countries during the last few years reveals a marked absence of uniformity in the ideas of different designers. Even if a generous allowance is made for local requirements and conditions, beacons of such varied design are in use as to suggest that they cannot all be both economical and efficient.

In the following notes solutions are suggested, based on a combination of theory and practice, to some of the fundamental problems involved.

There is no established method by which the economic intensity of a beacon can be calculated, but an approximate figure may be deduced from practical considerations.

When flying at night over inhabited country, at a height of, say, 3,000 feet, and in conditions of average visibility, a large number of lights can be seen which may be broadly divided into two groups. In the first group are local lights, such as street lamps, shop windows and the lights in houses, of which the intensity in an upward direction rarely exceeds 100 candles. These local lights cease to be visible at a range of five to six miles. (Fig. 1.)

Fig. 1.—Oblique Photograph from 3,000 feet.

Secondly, there are high-powered headlights on motor transport, giving beams up to about 50,000 candles, which are visible from the air as white flashes and occur at ranges of 5 to 20 miles. The presence of these flashes makes it difficult to identify a white flashing beacon when it appears within this zone.

An observer is liable to imagine that the horizon lies along the line where the last lights are visible, that is at 20 miles, whereas the true horizon is approximately 70 miles distant. There is, from 20 to 70 miles, a dark zone which is entirely free from visible lights.

If, therefore, an airway beacon is given sufficient intensity to make it visible when it is within the dark zone referred to it will appear as an isolated flashing light, standing well above all other lights and easily identified.

An airway beacon must fulfil several requirements. By its flashing character, colour, or by means of subsidiary lights, it must exhibit a signal enabling its locality, or alternatively the route on which it is placed, to be identified. When visibility is bad the light intensity must be sufficient to enable a pilot, by the exercise of ordinary navigational facilities, to pick up each beacon in turn when flying along a route. On a clear night the light should be visible and recognizable at long ranges.

To attain a long clear-weather range requires a high light intensity directed at a small angle above the horizontal, and beacons at present in use have intensities ranging from approximately 50,000 to 1,000,000,000 beam candles.

* The author is a member of the Technical Development Staff at the Royal Aircraft Establishment, South Farnborough. This paper has been approved by the Air Ministry for publication, but does not necessarily represent official views.

The lower limit of intensity for a beacon should not be less than 50,000 candles, when it will be at least as bright as the distant lights with which it may be confused. To ensure adequate separation from all other lights the intensity may be raised to as much as 100,000 candles.

It appears that little can be gained by materially exceeding this suggested figure except the possibility of spacing beacons at considerable distances apart, but, since the real need for beacons is felt when weather conditions are medium or bad, very long spacings are unsatisfactory in countries where bad visibility frequently prevails.

Having fixed limits for the beam intensity, the next question to consider is how the light should be distributed to the best advantage.

This value was determined experimentally by Mr. A. K. Toulmin-Smith and the author under conditions which were similar to those usually experienced by an observer from the air.* The value is higher than the marine standard of visibility owing to the many difficulties such as cockpit lighting, propeller glint and the wearing of goggles, which are attendant on observations of airway beacons.

The height at which machines using the route are flown determines the beam elevation. It has been assumed, for the examples which follow, that on a civil airway the maximum flying height at night will be 3,000 feet (h = 0.5682 mile).

The influence of atmospheric transmission is naturally variable, and the method of distributing the light from a beacon must be a compromise which will, as far as

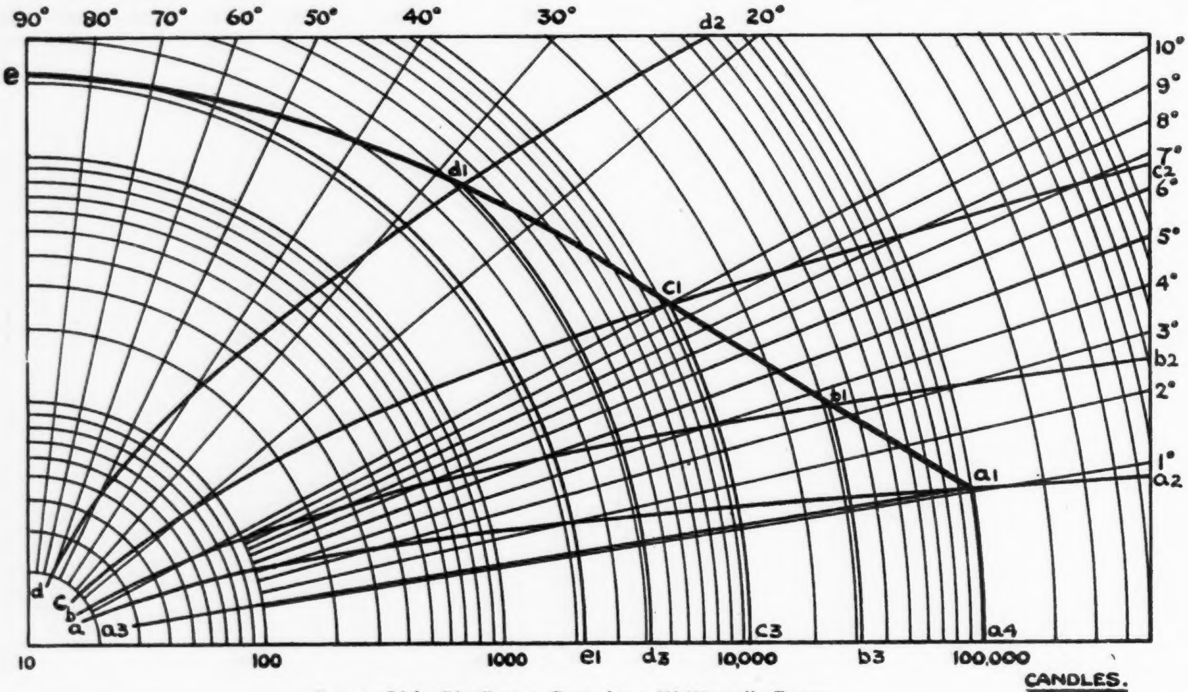


FIG. 2.—Light Distribution Curve for a 100,000-candle Beacon.

The visibility (V) of a point source, such as a beacon when seen at normal ranges, is proportional to:

(*a*) The total candle-power (I) of the source.

(*b*) The inverse square of the distance (d).

$$V = \frac{I}{d^2} \quad \ldots \quad \ldots \quad \ldots \quad \text{(i)}$$

The effect of atmospheric absorption may be computed by Beer's law:

$$I^1 = It^d \quad \ldots \quad \ldots \quad \ldots \quad \text{(ii)}$$

When the observed intensity I^1 at a distance d from the source of initial intensity I is an exponential function of the transmission t.

Combining (i) and (ii) the intensity required to be visible at any range under any given transmission conditions can be found from

$$I = \frac{Vd^2}{t^d} \quad \ldots \quad \ldots \quad \ldots \quad \text{(iii)}$$

and

$$d = \frac{h}{\mathrm{Sin}_\theta} \quad \ldots \quad \ldots \quad \text{(iv)}$$

where h is the height at which the observer is flying and θ is the beam elevation above the horizontal.

The light distribution given to a beacon is determined by:—

(*a*) The degree of visibility the beacon is required to give.

(*b*) The height at which pilots using the route will fly.

(*c*) The atmospheric transmission.

A satisfactory degree of visibility has been provisionally fixed as that of a light of 0.5 candle intensity when seen at a distance of one mile on a clear dark night.

possible, efficiently meet all weather conditions in which flying is likely to occur.

In this country, on a night when the visibility would be considered good, the atmospheric transmission is of the order of 0.85 per mile. This has accordingly been taken as a basis on which to compute the fair-weather light distribution.

From equations (iii) and (iv) a polar curve can be drawn which is theoretically correct for a transmission of 0.85 per mile and for an observer flying at 3,000 feet. The intensities are such that the beacon would have a visibility of 0.5 at all ranges. Refer Fig. 2, curve a, a_1, a_2, in which intensities are shown to a logarithmic scale, and an arbitrary angular scale has been taken to enable the intensity changes near the horizontal to be appreciated.

If the maximum beam intensity required is 100,000 candles, then the required distribution is given by curve a, a_1, a_3. But since a pilot may be flying below 3,000 feet the maximum intensity must be carried down to the horizontal to ensure that in every case the main beam will be picked up. The curve a, a_1, a_4 results, and represents the best possible distribution when t = 0.85.

The total flux represented by curve a, a_1, a_4 can be computed by a step by step integration, and is 13,600 lumens.

Assuming that the atmospheric transmission is reduced to 0.5 per mile and that it is required to find the best light distribution for a beacon having the same lumen output (13,600) as that previously described, the same procedure as before will be followed, curve b, b_1, b_2 being plotted, connecting intensity and range.

* *Aircraft Engineering,* Vol. 3, No. 23, January, 1931, p. 12.

Since more light is now required in the upper angles to compensate for the decrease in transmission, it is obviously impossible to retain an intensity of 100,000 candles in the main beam.

By computing three or more values for total flux at points along b, b_1, b_2, and plotting these against maximum intensity, a curve b, b_1, b_3 is obtained, which represents the same total flux as curve a, a_1, a_4. Curves c, c_1, c_3 and d, d_1, d_3 are similarly obtained for transmissions of 0.1 and 0.001 per mile.

At the limit when the main beam is carried from horizontal to zenith the required intensity is $13{,}600/2\pi$.

Each of the curves e, e_1, d, d_1, d_3, etc., represents the best possible distribution of a given flux of light to meet a given transmission condition. If, therefore, a curve is drawn through the points e, d_1, c_1, b_1, a_1, a_4, forming an envelope to the curves a, a_1, a_4, b, b_1, b_3, etc., it will give a light distribution which it is considered will represent the best compromise for a beacon of 100,000 candles maximum intensity, to be effective in varying conditions of atmospheric transmission.

The above general conclusions may be slightly modified by the distance apart at which beacons are spaced, and by the worst visibility in which flying is to be carried out. The worst visibility in which flying can be undertaken is largely a matter of opinion, but if a transmission of 0.02 per mile is taken as the low limit it will cover decidedly difficult conditions.

Fig. 3 shows a family of distribution curves for beacons of various intensities, both intensity and angular scales being logarithmic. Referring to the curve for 100,000 candles maximum, it will be seen that when the transmission is 0.02 per mile the range from 3,000 feet is approximately two miles. A competent navigator is able to fly within 5° of the true course, the distance apart at which the beacons should be placed is therefore approximately 23 miles.

The curves shown in Fig. 3 enable certain conclusions to be drawn as to the power and type of light sources suitable for use in airway beacons. The source must obviously be small to enable the ideal distribution to be approximated without using extravagantly large reflectors or lenses. It must also emit a sufficient flux of light to fill the ideal distribution curve, allowing for absorption losses in the optical system.

Taking the case of a beacon of the fixed dioptric lens type, with a spherical mirror to collect light over the angle opposite to the lens and a shutter system to give the required character, the ratio of the lumens in the beam to the lumens output of the source is 0.31 : 1.

The flux of light required to fill the ideal curves shown in Fig. 3 is given in the table below, together with the lumen output and energy consumption of the source, assuming that a gasfilled lamp is used operating at an efficiency of 19.5 lumens per watt.

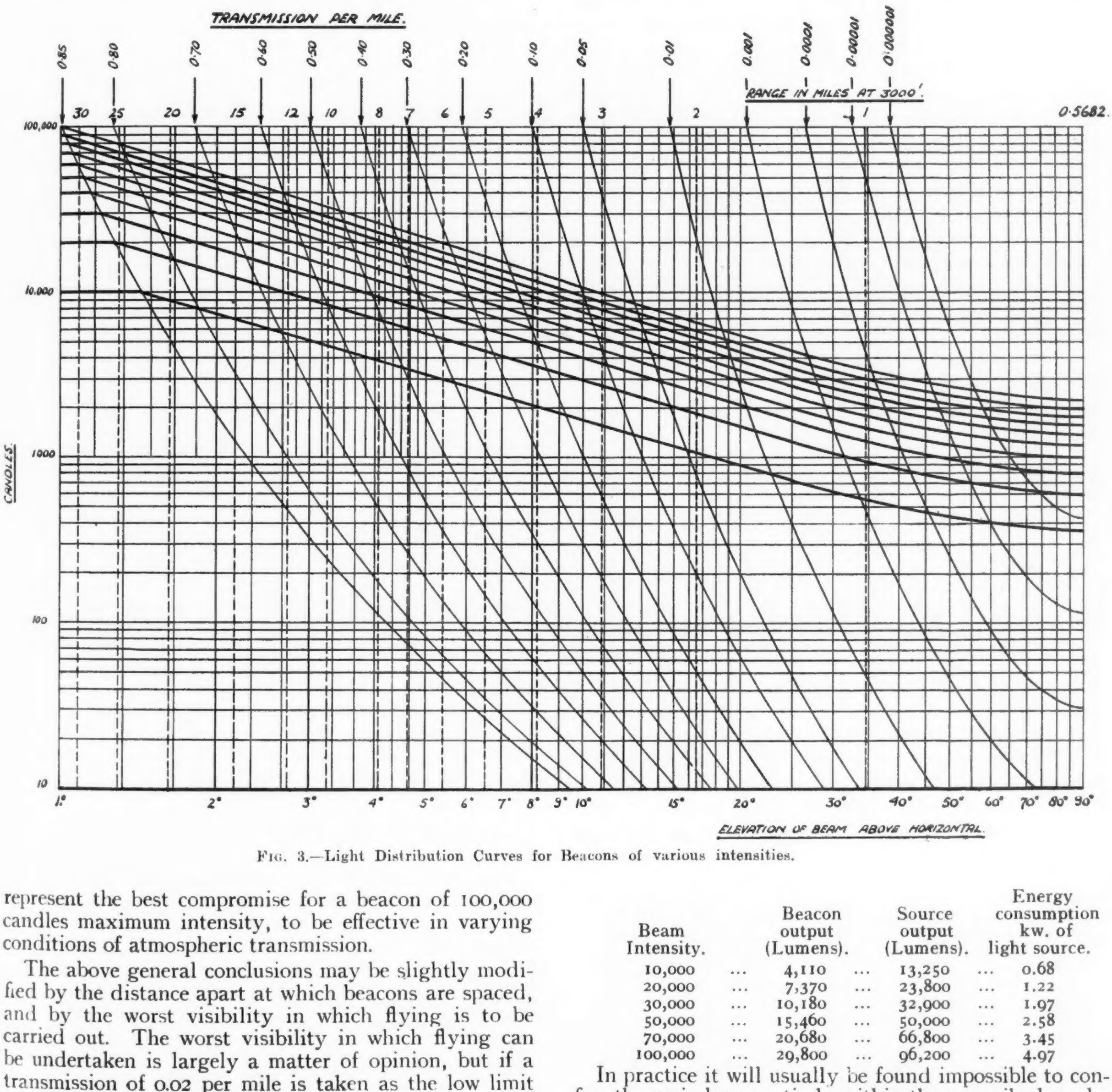


Fig. 3.—Light Distribution Curves for Beacons of various intensities.

Beam Intensity.	Beacon output (Lumens).	Source output (Lumens).	Energy consumption kw. of light source.
10,000	4,110	13,250	0.68
20,000	7,370	23,800	1.22
30,000	10,180	32,900	1.97
50,000	15,460	50,000	2.58
70,000	20,680	66,800	3.45
100,000	29,800	96,200	4.97

In practice it will usually be found impossible to confine the main beam entirely within the prescribed angle, and the energy consumption must accordingly be slightly increased to compensate for this spilled light.

In conclusion, it may be mentioned that night-flying pilots are almost unanimously of opinion that present-day beacons have a tendency to be very visible in clear weather, when they are not very necessary, and to disappear in bad weather, when they are most wanted. The curves show intensities in the upper angles, which are effective in bad weather, considerably in excess of the intensities usually allowed by existing practice.

Some Notes on the 21st Annual Exhibition of the Physical Society and the Optical Society

(Held at the Imperial College of Science, South Kensington, during January 6th-8th, 1931.)

(Communicated.)

SPECIAL interest attached to the above exhibition in view of the fact that it attained this year its 21st anniversary. During this period of years the exhibition has proved its value, and has come to be looked for as an annual demonstration of what is new in connection with optical and physical apparatus. Professor Sir Arthur Eddington opened the exhibition on January 6th. Discourses, illustrated by experiments, were given by Mr. E. Lancaster Jones on "Searching for Minerals with Scientific Instruments," and by Prof. Sir Gilbert Walker on " The Physics of Sport."

The exhibition proved to be quite as comprehensive as in previous years, and there were, as usual, a number of exhibits of interest to illuminating engineers. One looks first for such items in the Research Section.

In the National Physical Laboratory's exhibit the most important item from the illumination viewpoint was the new spectrophotometer, due to Mr. H. Buckley and Mr. F. J. C. Brookes, which was recently described in the *Journal of Scientific Instruments.*

Hot-Cathode Discharge Lamps.

A considerable proportion of the exhibit of the research laboratories of the General Electric Company was devoted to illumination work. Many of the new hot-cathode low-voltage discharge lamps were on view. These tubes, which operate on voltages as low as 200 volts, are about 2 ft. long, and can have the characteristic red neon colour, the blue mercury colour or the new yellow sodium colour. By means of colour filters, other colours, e.g., green and a species of white, can be obtained. The efficiency of the lamps is high, that of the sodium lamp reaching 30 lumens per watt. By means of a combination of incandescent lamps and a mercury-vapour lamp an artificial-daylight unit had been constructed. By another combination of tubes, sodium and neon, a candle-light effect had been produced.

The following approximate figures for the luminous efficiencies of the tubes are of interest:—

	Lumens per watt.
Neon (red)	10–12
Neon-Mercury (blue and green) ...	9–15
Sodium (yellow)	30–40

(The efficiency of a gasfilled tungsten-filament lamp of 100-watt rating is about 12 lumens per watt, but is considerably less than this if the lamp is combined with a filter to give a coloured light.)

An interesting demonstration had been arranged in connection with a gasfilled lamp. Small fans had been built into various parts of a 1,000-watt lamp, and by their rotation the velocity and direction of the gas stream could be detected. The high velocity just above the filament was very marked.

Photometric Apparatus.

As usual, the laboratories had some new developments in photometric apparatus, and a 1-metre photoelectric integrating photometer was shown in operation. This photometer will measure lumens or lumens per watt, and should prove of considerable value in lamp rating. A telephotometer for brightness measurements at a distance (e.g., in artificially lighted streets), and a simple yet effective design for a photometric test plate, were also exhibited.

Photoelectric cells also figured in the exhibit of the British Thomson-Houston Co. Ltd., an apparatus being shown whereby differences between types of cells in respect of sensitivity to different colours, etc., may be recorded, or the amount of light received by a cell may be controlled by the light reflected or transmitted by substances—the current from the cell being amplified about 100,000 times and caused to drive a motor, the speed of which is governed by the amount of light falling on the cell.

An experimental television set was exhibited by Mr. R. W. Corkling, whilst Mr. T. M. Lance contrived a demonstration of the limitations imposed on definition by the finite size of the scanning spot in a television system employing Nipkon discs.

The Gas Light & Coke Co.'s Exhibit.

There were a number of interesting items in the Gas Light and Coke Co.'s exhibit. The development of a rubber tube which can withstand being trodden on or kinked without stopping the flow of gas, is a considerable achievement. The principle involved is that of a small-diameter solid-rubber cylinder, which runs inside the tube. It is attached by a web to the tube itself, and is of sufficiently small diameter to cause little obstruction; it is effective, however, in maintaining a through passage for gas when the tube is compressed. A second exhibit showed apparatus for determining the absorption of gas by rubber tubing. By measurements of this character the relative extents to which the gas will diffuse through the rubber can be determined. Methods of testing vitreous enamels for resistance to abrasion, shock and chemical attack were also shown. If some such methods were standardized they might prove of value in connection with specifications for the vitreous enamels in general use for illumination work.

The General Exhibits.

Amongst items in the general and trade section of the exhibition, there were also included photoelectric cells and many pieces of apparatus in which cells were incorporated. Continued developments have been made with lantern and episcopic projectors. In the case of the latter, higher screen illuminations are being recorded every year.

Bakelite Ltd. continue to apply Bakelite mouldings as electrical insulators in apparatus, and to a considerable extent metal parts are also being replaced by it. Transparent Bakelite was being shown, and this may prove in the future to be of value in illumination work. Messrs. R. & J. Beck showed a number of microscopes and illuminators. One new lamp uses a mercury-vapour tube with a didymium-glass screen to obtain a practically monochromatic source of light suited especially for high-power microscope work. A very good design of lamp house for use with incandescent filament lamps was also shown. The essential characteristic of keeping the lamp-bulb temperature to a minimum was obtained both by efficient ventilation and by careful ribbing of the lamp house to increase radiation.

The new Luxometer for illumination measurements was exhibited by Messrs. Everett, Edgcumbe & Co. Ltd. The instrument, which complies with British Standard Specification No. 230/1925, is available in two ranges. The one shown had a scale range of 0.005 to 2 foot-candles with magnifiers for x10, x100 and x1,000. A matt opal-glass test surface is supplied with the instrument.

Messrs. Kelvin, Bottomley & Baird had their usual display of ultra-violet inspection lamps for determining the presence of fluorescence in materials. In addition to other apparatus, a shadowless lighting unit was again exhibited.

The proportion of items in this year's exhibition devoted to illumination work is some indication of the growing importance which is being attached to the subject, and it is hoped that progress will be continued throughout the year.

POPULAR & TRADE SECTION

COMPRISING

Installation Topics—Hygiene and Safety—
Data for Contractors—Hints to Consumers

(The matter in this section does not form part of the official Transactions of the Illuminating Engineering Society and is based on outside contributions.)

Decorative Lighting at the Stockholm Exhibition (1930)

FIG. 1.—A General View of the Grounds, showing the Floodlighting of the Statue by means of the Projector.

BY the courtesy of the *Svenska Foreningan for Ljuskultur*, we are reproducing two views of the lighting at the exhibition, held in Stockholm in 1930, which was the subject of reference in our journal some months ago. Fig. 1 is interesting as an example of the part played by water in this exhibition, the isolated statue standing out well in the beam of the projector located under the bridge. Water again plays a part in Fig. 2, where the luminous rectangular column is flanked by an illuminated cascade.

These and other views appear in an illustrated booklet descriptive of the exhibition, in which floodlighting and luminous line-work play a leading part. We notice the adoption of somewhat singular indirect "mushroom" units for park-lighting, the lamp being screened in a metal cup and its light received and diffused downwards by an extensive inverted canopy, situated on the summit of a tall mast. Another feature of interest at the exhibition was the Zeiss "planetarium," which permits the movements of the heavenly bodies to be depicted in a truly wonderful manner.

The booklet is instructive in showing the importance attached to illumination as an element in exhibitions, and the progress in illuminating engineering that is evidently being made in Sweden.

It will be observed that some of the features of the lighting at this exhibition—such as the use of luminous columns and of indirect fittings on poles—are on similar lines to those evolved in connection with the recent festival lighting in Belgium. We hope to make fuller reference to the latter in a forthcoming issue of our journal.

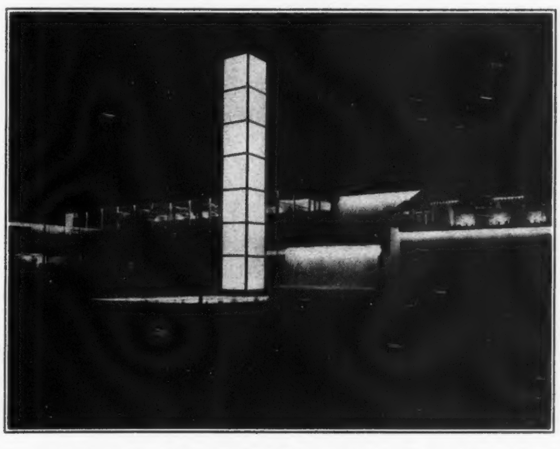


FIG. 2.—Showing a Luminous Column adjacent to an illuminated cascade, with Concert Hall in the background.

Illuminations in Cairo

We are indebted to one of our correspondents in Egypt, Mr. N. E. Unter, for the three accompanying illustrations, showing decorative lighting in Cairo. Mr. Unter explains that there are three chief occasions during the year on which decorative lighting is adopted. The first of these is October 9th, the King's birthday. The second occasion is March 26th, the date of His Majesty's accession to the throne. The third usually occurs sometime in November, when the King returns to the Capital from his summer resort at Alexandria.

The photographs here reproduced were all taken on October 9th, 1930, and illustrate the lighting of the Kehia Mosque (Fig. 1), the illumination of the front of the Opera House (Fig. 2), and one of the two luminous crowns erected in the Opera Square (Fig. 3). The frontage of the Opera House bears the words "Long Live King Fuad I" in Arabic characters.

These pictures are interesting as an indication of the development of artificial lighting in the East, which has been quick to seize upon this method of marking festive occasions.

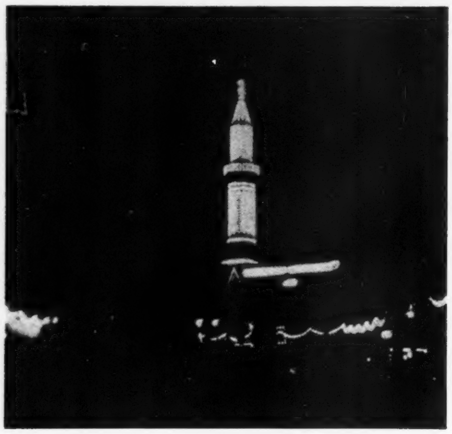


Fig. 1.—The Minaret of the Kehia Mosque, Cairo, illuminated at night.

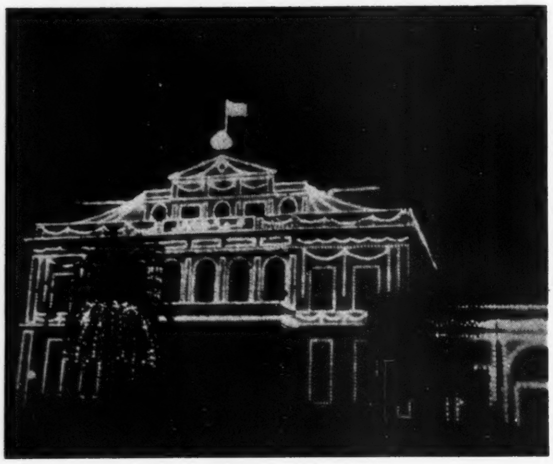


Fig. 2.—The Opera House, Cairo, illuminated on the occasion of the King's birthday (October 9th, 1930).

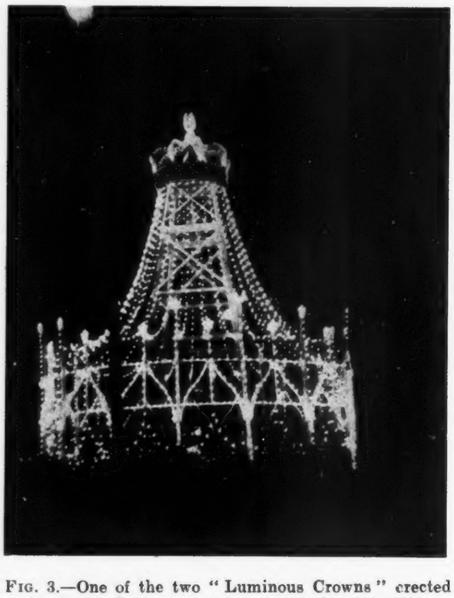


Fig. 3.—One of the two "Luminous Crowns" erected in the Opera Square, Cairo, on October 9th, 1930.

Hotel Lighting

At the recent E.D.A. Sales Conference, on December 19th, Mr. R. C. Hawkins introduced a discussion by an address, entitled "Sales Aspects of Hotel Lighting." The author pointed out that hotels offered an excellent field for the efforts of the lighting expert. No doubt many new hotels will be built during the coming years, and the demands of the public in regard to comfort and convenience are continually increasing. Data bearing on 318 hotels in Great Britain, roughly classified into two divisions according to Automobile Association ranking, were presented. The 46 hotels in the first group showed up much better as regards lighting than those in the second (272 in number). Less than half of the first group and less than one-quarter of the second used lighted exterior signs, whilst for interior signs the figures were 46 per cent. and 1 per cent. respectively—the latter certainly a remarkably low figure. In 83 per cent. of hotels in the first group, and in only 53 per cent. of those in the second group could one read comfortably in the lounge. In Group I only 19 per cent., and in Group II only 1 per cent. of bedrooms were equipped with three fittings—and two-thirds of hotels in the second group had only one! In 83 per cent. of hotels in the first group one could read comfortably in bed, but only in 36 per cent. of the remainder was this possible. In conclusion, Mr. Hawkins pointed out that in Great Britain there are approximately 6,400 hotels of all types. The A.A. Association handbook lists 2,195 hotels, with 87,251 bedrooms, so that there is ample scope for educational effort in an hotel-lighting campaign.

Most of those who joined in the discussion agreed as to the need for better lighting in the majority of hotels, especially as regards bedroom lighting. Some, however, may be inclined to share the view of Mr. L. L. Robinson, who complained that all the joys of this world were being sacrificed for stunt advertising in lighting—that one required a hotel to be a place of comfort, and not a "dazzling, glittering place."

Expert Translators

We are asked to mention that a Panel of Expert Translators has been formed by the Association of Special Libraries and Information Bureaux (26, Bedford Square, London, W.C.1). The details of the scheme are set out in a leaflet issued by the Association to whom those interested (either as expert translators themselves or as being in need of such help) are invited to apply.

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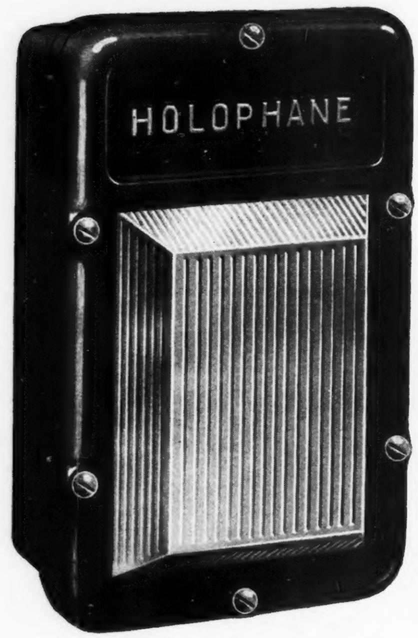
TRADE NOTES & ANNOUNCEMENTS

THE HOLOPHANE PRISMATIC BULKHEAD FITTING.

A leaflet recently issued by Holophane Ltd. gives particulars of a new directional device for special purposes, the Prismatic Bulkhead Fitting, a general view of which accompanies this note. The fitting is intended primarily for use in cases where there is limited headroom, and where a well-directed lateral light is required to illuminate regions between units. Light control is effected by a back reflector and a front refractor in combination. Both are of the prismatic type, and the accentuation of the lateral light is shown, in the original leaflet, by polar curves. Attention is also drawn to the good mechanical qualities of this compact lighting unit, e.g., its robustness and the ease with which one can get access to the interior and keep the surfaces clean.



The New Holophane Bulkhead Fitting.

G.E.C. DOCK LIGHTING.

A well-illustrated booklet dealing with the dock lighting at the Port of London has been issued by the General Electric Co. Ltd. It is recalled that the Port of London Authority, constituted in 1908, came of age on March 31st, 1929. It now controls a length of the River Thames of 69 miles, and possesses a total dock area of some 3,688 acres. An illustration of the special dock-lighting unit, designed by the General Electric Co., Ltd., and installed at Tilbury and West India Docks, is included. This opaque reflector completely screens the source of light, and is specially designed for use with zig-zag 500-watt gasfilled lamps. The form of polar curve illustrated, with a maximum near 65°, is particularly suitable for the wide spacing needed in illuminating the vast areas usual in docks. The booklet contains a number of attractive pictures showing the appearance of the illuminated wharves by night, the platforms being flooded with light and the effect substantially free from glare. Attention is drawn to the great services rendered by effective dock lighting in expediting night work, preserving order, and making difficult thefts under cover of darkness.

"THE REFLECTOR."

Further "reflections" are to be found in the latest number of the above bright publication issued by Benjamin Electric Ltd. There is a description of the Benjamin Photometric Laboratory, and a detailed account of a comparative test of the Benjamin 18-in. R.L.M. and a dispersive reflector of Continental origin, in which the former comes out top.

HOME OFFICE REGULATIONS FOR SKIRTED LAMPHOLDERS.

We have also received from Benjamin Electric Ltd. a pamphlet drawing attention to the above regulations; these are explained, and it is shown how the requirements are complied with in Benjamin models.

NEW BRANCHES AND ADDRESSES.

New Mazda Depot at Leicester.

On Monday, January 26th, a new Mazda Lamp Depot was opened at 38, Friar Lane, Leicester. Large stocks of all types and sizes of Mazda lamps are carried, and prompt attention will be given to all orders and enquiries.

G.E.C. Madras Branch.

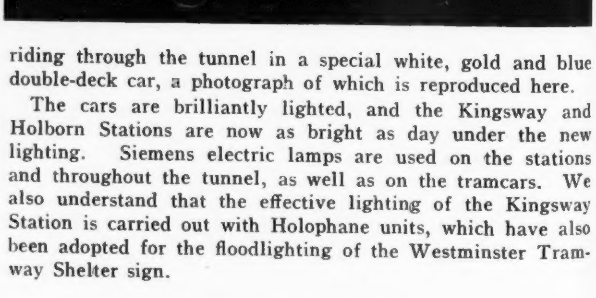
The General Electric Co. (India) Ltd. has just removed its Madras branch from 100, Armenian Street, Madras, to Magnet House, Mount Road, Madras.

The "Typerlite" Co.—New Accommodation.

We are informed that the "Typerlite" Company has taken further accommodation at Nos. 26–27 and 30, Bush Lane, London, E.C. The former address will be used as a display room for "Typerlites," the latter for workshops and stores.

THE NEW KINGSWAY SUBWAY.

The official reopening of the Kingsway Subway for double-deck tramcars took place on January 14th, thus restoring direct tramway communication between North and South London, but on a larger scale than before. Major R. I. Tasker, Chairman of the L.C.C., performed the opening ceremony by



riding through the tunnel in a special white, gold and blue double-deck car, a photograph of which is reproduced here.

The cars are brilliantly lighted, and the Kingsway and Holborn Stations are now as bright as day under the new lighting. Siemens electric lamps are used on the stations and throughout the tunnel, as well as on the tramcars. We also understand that the effective lighting of the Kingsway Station is carried out with Holophane units, which have also been adopted for the floodlighting of the Westminster Tramway Shelter sign.

CONTRACTS CLOSED.

Messrs. Siemens Electric Lamps and Supplies Ltd. inform us that the Dublin Port and Docks Board, the Booth Steamship Co. Ltd., and the Dublin United Tramways Co. (1896) Ltd. have all placed contracts for 12 months' supplies of Siemens electric lamps.

Sheffield Illumination Society

The annual social evening arranged in connection with the Sheffield Illumination Society was held at Stephenson's Restaurant, Sheffield, on the 5th January, when about 100 members and friends spent an enjoyable evening.

Councillor R. H. Minshall (Chairman of the Lighting Committee), who presided, referred to the great improvement in the street lighting of Sheffield since Mr. Colquhoun was appointed, and pointed out that the number of lamps in the city had been increased from 11,000 in 1924 to 19,000 at the present time.

Musical items followed, contributed by Miss Margaret Watson, Mr. Ernest Wilkinson, Mr. Clifford Kemshall, and Mr. Stan Hatton entertained with ventriloquial items and humorous sketches. Mr. Ernest Marrison acted as accompanist.

After the concert refreshments were served in the lower hall of the restaurant, and the evening terminated with a whist drive, the M.C.'s being Messrs A. L. Williams and A. C. Burrell. Miss Gillott presented the whist prizes.

MAZDA LAMPS AT THE BRITISH INDUSTRIES FAIR.

Novel in design, construction and lighting, the Mazda Lamp Stand (19 J1) will doubtless impress itself upon the memories of all who visit the Fair at Castle Bromwich. The accompanying photograph is from a very small preliminary model, and does not do justice to the design of the stand, and still less to the lighting, which is, of course, the chief and most attractive feature. Apart from the very unusual nature of the counters, which consist of two converging lines of triangular sections of diminishing size, the material of which they are made is also novel. These counters are illuminated from within, and it was at first proposed to make them of glass, which has many disadvantages. Subsequently it was decided to use the new translucent material which gives the effect of glass without the fragility.

The whole of the lighting of the stand is arranged on four circuits, employing Mazda colour-sprayed lamps of four different colours. These circuits are connected to a motor-driven dimmer. The colour-changing effect is very effective. Mazda lamps of all types, with one or two exceptions, are displayed on the illuminated counters. The tableau at the rear end of the stand is yet another representation of the world-famous Mazda " Dancing Girl " picture.

THE IDEAL HOME EXHIBITION.

The Ideal Home Exhibition, which is to take place at Olympia during April 7th to May 2nd, promises to be again full of interesting features. A sequel to the " House that Jill built," which proved a popular competition last year, is " the House that JACK built," which is to be the result of a competition organized by the *Daily Mail,* in which husbands are now competing. Other features in prospect are " Caravan Town," " The Gardens of the Counties," the " Theatre of Fashions," and " Famous Rooms in Fiction." We gather that lighting and colour effects will figure quite as prominently as on former occasions, and that specially ingenious measures will be contrived to guide the visitor to various sections of the exhibition.

The series of exhibits of " Nurseries for All Purses " and " The Evolution of the English Dining Room " from the time of the ancient Britons onwards, should also afford scope for considerable variety in lighting.

Photograph of Miniature Model of one of the most novel and attractive exhibits in the Castle Bromwich Section of the British Industries Fair.

INDEX (February, 1931).

The Illuminating Engineer

The Journal of

GOOD LIGHTING

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Published on the 1st of the month.

Copy due 15th of the previous month.

Proofs to be passed by the 20th of the month. In the event of proofs not being passed by this date it will be assumed that matter is repeated.

SPECIAL INFORMATION.

THE ILLUMINATING ENGINEER (the Journal of GOOD LIGHTING) was founded in January, 1908, and has thus been in existence for twenty-three years.

SINCE the year 1909, when the Illuminating Engineering Society was founded in London, it has been the official organ of the Society.

IT is ***the only journal in this country exclusively devoted to Lighting by all Illuminants.***

IT receives the assistance of contributors who are leading experts on illumination in this country and abroad. Foreign Notes and News will be a speciality, and correspondents have been appointed in all the chief cities of the world.

THE Journal contains *first-hand and authoritative information on all aspects of lighting;* it has also been improved and extended by the inclusion of a *Popular and Trade Section* containing special articles of interest to contractors, gas and electric supply companies, Government Departments and members of the Public.

DISCUSSIONS before the Illuminating Engineering Society which are reproduced in this Journal are participated in alike by experts on illumination and *users of light*, whose co-operation is specially invited.

Good Lighting is of interest to everyone. The Journal is read by engineers, architects, medical men, factory inspectors, managers of factories, educational authorities, public lighting authorities, and large users of light of all kinds.

BESIDES being issued to all members of the Illuminating Engineering Society, the Journal has an independent circulation amongst people interested in lighting in all parts of the world. The new and extended form of the Journal should result in a continual and rapid increase in circulation.

Every reader of THE ILLUMINATING ENGINEER, the Journal of GOOD LIGHTING, *is interested in illumination, and is a possible purchaser of lamps and lighting appliances. Gas and Electricity Supply Undertakings likewise benefit by the movement for Better Lighting, with which the Journal is associated, and which stimulates the demand for all illuminants.*

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Members receive *The Illuminating Engineer*, the official organ of the Society, free.

The Society preserves an impartial platform for the discussion of all illuminants, and invites the co-operation both of experts on illumination and users of light; it includes amongst its members manufacturers, representatives of gas and electric supply companies, architects, medical men, factory inspectors, municipal officers, and many others interested in the use of light in the service of mankind.

The Centre for Information on Illumination.

For particulars apply to:

J. STEWART DOW, *Hon. Secretary,*

32, Victoria Street, LONDON, S.W. 1.